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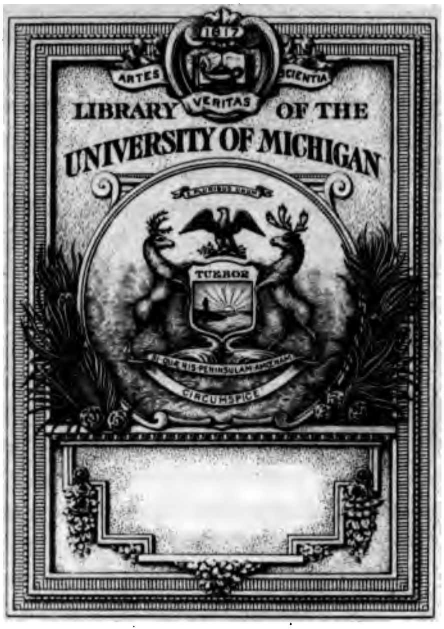

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GEOLOGICAL SURVEY OF HOKKAIDO.

A

GENERAL REPORT

ON THE

GEOLOGY OF YESSO;

BY

BENJAMIN SMITH LYMAN,

CHIEF GEOLOGIST AND MINING ENGINEER.

TOKEI:
PUBLISHED BY THE KAITAKUSHI.
1877.

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GEOLOGICAL SURVEY OF HOKKAIDO.

A General Report on the Geology of Yesso; accompanied by a Colored Geological Sketch Map of the Island, a Geological and Topographical Map of Part of the Ishcari Valley and a Map of the General Commercial Position of the Yesso Coal; by Benjamin Smith Lyman, Chief Geologist and Mining Engineer.

His Excellency
K. Kuroda,
Kaitakuchokuwan.

Sir,

I have the honor to make you the following short general report on the geology of Yesso.

1. *Situation.*—The island of Yesso, between the Pacific Ocean on the south-east, the Japan sea on the west and the Okhotsk sea on the north-east, may be said to lie as if it were fixed in position by three skewers, to use perhaps too kitchenlike an expression. One skewer coming from the north-east is that on which the Kuril Islands are strung; another from the north has passed lengthwise through the island of Sagalin (or Karafto); and the third, a little to the west of that, comes from the south after traversing the whole length of the northern third of Nippon. And again the shape of Yesso may be likened to

that of a large frying pan with a short crooked handle. The pan itself instead of being round is nearly lozenge shaped with one point, Cape Erimo, towards the south; another, on which the village and harbor of Nemoro lie, points to the east; a third, on the north, bears the town and roadstead of Sôya within thirty miles (12 ri) of Sagalin; and the fourth, towards the west, merges (say, at Sapporo, the capital) into the handle which bends southward around Volcano Bay to within fifteen or twenty miles of Nippon, forking towards the south, with Matsmai at the extreme south-western end and Hakodate in the crotch. The whole Island contains (according to Matsura's Map of 1860, when reduced to a projection that is as little distorted as possible) about 30,550 square English miles, or about 5,100 square ri.

The geological survey has been limited to Yesso, and no opportunity has been given of visiting other parts of Hokkaido, which formerly included Karafto and latterly takes in all the Kuril Islands, as well as the small islands adjacent to Yesso. It has been possible however in travelling round the coast to see something of the character of the nearer islands and by inquiry to learn something further in regard to them.

2. *Lay of the Land.*—The traveller on first approaching Yesso from the south and coasting from Hakodate along the western shore of the pan handle gets the impression that Yesso is almost nothing but a confused mass of rugged mountains; and a complete circuit of the Island tends on the whole, but with some important modifications, to confirm that impression. Many of the mountains are snow-capped until June, and a few, in the centre of the Island, until August and probably all the year round. It is difficult, if not even impossible, on the ground to perceive any straightness or parallelism in the ranges of mountains; and perhaps there are very good geological

reasons for the fact. A very large number of the mountains are made up of volcanic rocks which have probably issued from more or less irregularly arranged vents or fissures and have assumed on the surface still more irregular shapes that no amount of denudation would reduce to any uniformity of outline. A large portion of the strictly sedimentary rocks are perhaps raised in long parallel folds which with denudation sufficiently protracted to obliterate its own first irregularities would give rise to long parallel mountains with level crests (like those of Pennsylvania) ; but the rocks and their folds are of such late origin that denudation has continued far too short a time to produce so uniform results (as in the Pyrenees and the Western Alps). Besides, even some of these comparatively new rocks have been affected by more than one system of folding ; so that although the denudation had advanced far enough the anatomy displayed by it would be complicated and apparently irregular.

Three or four of the high central peaks (probably volcanic) seem however to be nearly or quite in a north-east and south-west line ; Ishcaridake in the middle, Tokachidake north-easterly and Yubaridake south-westerly, all probably about 8,000 feet high. It is possible too that Tarumai volcano about 3,000 feet high, near the sea coast south of Sapporo, and Komangadake volcano some 3,000 feet high, just south of Volcano Bay, are in the same line with them. Itashibeoni volcano, about 6,500 feet high, with the promontory on which it stands, north of Nemoro, Sharidake, 25 miles to the south-west of it and perhaps 5,000 feet high, and the fine volcanic cone Oakan and Meakan, fifty miles east of Ishcaridake are perhaps in another such north-east and south-west line, of which Esan volcano (about 2,000 feet high) at the extreme south-eastern end of the pan handle may be a prolongation. The nearest Kuril Island, Kunashiri, with a couple of volcanic cones on it, and the next, Edorop, have also a very marked north-east and south-west direction *en echelon* with the Itashibeoni promontory; and the Nemoro peninsula is about in line with Edorop. Shiribetsudake, perhaps the most beautiful volcanic cone of Yesso and some 6,000 feet high stands a dozen miles north of the ragged Usu volcano, (possibly 2,000 feet high) of the north-east shore of Volcano Bay; but is rivalled, if not surpassed, in symmetry, and height, by the volcanic island Riishiri, a few miles west of the northern end of Yesso. Iwanobori is a volcano about 4,000 feet high and some ten miles north-west of Shiribetsudake. Nuburibetsudake, say 2,000 feet high, is half way between Tarumai and Komangadake, but a few miles to the north-west of the line. The principal volcanic peaks have now been mentioned; but there are many other mountains of 2,000 or 3,000 feet in height, and several 4,000 or 5,000 feet high.

Yet a great island with high snowy mountains could hardly fail to have at least a few large rivers, which would scoop out wide valleys. The Ishcari River, the largest one in Yesso and about 190 miles long, empties into the Japan sea at the village of Ishcari half a dozen leagues north of Sapporo, and comes with a crooked south-westerly course from the central part of the Island. From the same region the Teshio river flows northerly into the Japan Sea nearly opposite Riishiri; and the Tokachi, south-easterly into the Pacific Ocean about the middle of the south-eastern side of the lozenge. The Kusuri, another pretty large river, fills with its branches a wide space near Oakan and Meakan to the east of the Tokachi, and has a southerly course. The Shiribets. the largest of the rivers of the pan handle, drains the middle of its northern wide end and with a westerly course, passing north of Shiribetsudake, empties into the Japan sea.

The lower part of the Ishcari valley is a wide alluvial plain (mostly swamps) perhaps 600 square miles in extent or, including the upland alluvium, about 1,150 square miles in all, and in the lower part of the upper valley is likewise an alluvial plain but only of some 100 square miles of surface. The Teshio River, has near its mouth such a plain, with probably some upland alluvium, of perhaps 250 square miles in all. The Tokachi valley not only has wide bottom lands, but a large border of flat uplands, probably very ancient river bottoms, amounting all together to perhaps 550 square miles. The Shiribets has comparatively narrow bottom lands, but with the adjacent flat uplands reaching into the Iwanai valley on the north and towards Usudake on the south must amount to something like 200 square miles. Nearly every river, in short, has more or less of such bottom lands or flat uplands, and in the whole of Yesso they would all count up to perhaps nearly 4,000 square miles or about 650 square ri, or one eighth of the whole Island. Probably still a much larger portion of the Island may become cultivated as has happened in Nippon. A large portion of the eastern corner of the Island, towards Kusuri and Nemoro is made up of only low rolling hills up to perhaps 300 feet high above the sea. The greater part of the north-east coast has a narrow plain along the sea shore, from a few hundred yards to a few miles in width ; and so have the northern fifty miles of the west coast, and Volcano Bay and the coast east of it.

The seashore even where not bordered by such plains is in general remarkably free from indentations of moderate size, notwithstanding its irregularity on a large scale ; and is consequently very poor in harbors. Hakodate (a town of perhaps 30,000 inhabitants) has a fine harbor ; and so has Mororan, a small village at the eastern end of Volcano Bay, and Akkeshi, a village between the Kusuri River and Nemoro has a moderately good one; and Nemoro another. But the other principal ports of Yesso are at best little more than open roadsteads. The best on the west coast is that of Otarunai a town of perhaps 3,000 inhabitants, twenty miles west of the mouth of the Ishcari. Hurubira (or Furubira) a town of nearly the same size about twenty miles further west has the next best. Esashi, also on the west coast some thirty miles north of Matsumai, and Matsumai itself are both sea ports said to be nearly as large as Hakodate, each with a somewhat sheltered anchorage. Iwanai twenty miles south of Hurubira boasts that its roadstead, though smaller, is nearly or quite as safe as Otarunai or Hurubira. Urakawa, a large town, thirty miles north-west of Cape Erimo has a somewhat sheltered nook in the coast. Hamanaka (or Ashirikotan) a village twenty miles east of Akkeshi has an anchorage pretty well sheltered by an island. Rurumoppe a town of a couple of thousand inhabitants, fifty miles north of Ishcari has a very open port. Ishcari itself has a wide, deep and safely sheltered space for vessels in the river near its mouth; but the water on the bar outside is commonly too shallow for vessels of any size, though sometimes twelve feet deep.

The principal towns have now all been mentioned; for with the exception of Sapporo they are all on the sea coast. There are, indeed, a few small farming villages a short distance inland, especially around Sapporo; but the rest of the interior is wholly uninhabited by men except a very few hundred aborigines (Ainos) scattered through the Ishcari, Tokachi and perhaps some other valleys. Even their villages are mostly on the sea shore; and their whole population is said to be some 17,000. The whole population, including both Japanese and Ainos, is said to be about 121,000.

As the towns are almost all on the coast, the only roads are with two or three exceptions bridle paths along the shore. A new road wide enough and well enough graded for waggons was built three or four years ago from Hakodate across to Volcano Bay, and then from Mororan along the coast fifty miles and thence to Sapporo, thirty-six miles more. A smaller one was was also built from Sapporo to Otarunai. There is a bridle path across from the head of Volcano Bay to the west coast and one from Esashi across to Hakodate, and one or two still smaller ones across other peninsulas. But the main body of the Island is still wholly unopened by roads of any kind; a fact that has important bearings in many ways upon the facility of making a geological survey.

3. Geology.—The rocks of Yesso seem to belong to seven different groups, as follows :—

New Alluvium perhaps up to	100	feet in thickness.
Old Alluvium ,, ,,	100	,,
New Volcanic Rocks ,, ,,	200	,,
Toshibets Group probably about	3,000	,,
Old Volcanic Rocks perhaps	3,000	,,
Horumui (or Coal Bearing) Group, probably about	6,500	,,
Kamoikotan (Metamorphic), perhaps	3,000	,,

The thickness, except those of the Toshibets and Horumui Groups, are mere guesses that are not based on any measurements.

a. New Alluvium.—The New Alluvium (or wash, as it might be called more simply), is the soft earthy material that is constantly slipping or washing in a thin sheet down the surface of the hills and accumulating at the present time in the level bottom lands of rivers. Much the largest amount of it anywhere on the Island is in the plains of the lower part of the Ishcari valley. Although it is there mostly covered with swamps in which an iron pointed, ten foot bamboo rod is easily pushed down its full length, they seem generally to be at their borders high enough above the water of the Ishcari and its branches, and to rise rapidly enough (two feet in a thousand) towards their centre to be capable of being throughly drained. Indeed, wherever the valley of any stream has penetrated, however a small gulch it may have made, scarcely larger than a small artificial ditch, the banks are firm for the distance of some yards, and in the case of larger streams for about 300 yards; but not more than that, even in the Ishcari itself. The swamps themselves are commonly very barren owing to the amount of water upon them; but the firmer strips of drained ground along the streams bear a luxuriant growth of large trees and of rank weeds, wild hemp and ferns. The soil therefore as in most bottom lands, is not by any means lacking in fertility; and the swamps could, with hardly a doubt be converted into fine farms by a system of drainage that would not be too costly. The drainage question is also of great importance with reference to the building of roads; for a great deal may in many cases be saved in distance and consequently in the expense of carriage, if waggon roads and railroads can be successfully built in straight lines acros the swamps instead of having to wind along their borders.

The new alluvium of the other valleys forms fertile plains, mostly near the sea coast; and they are in general free from the excessive wetness that gives rise to the Ishcari swamps. The largest amount of such bottom land is perhaps on the Tokachi river and its branches; and it is covered with a tall rich growth of grass. There is also a wide extent of such land near the mouth of the Teshio River; and almost every stream has its share. Probably throughout them all there is no great difference in respect of fertility (leaving the drainage out of account): since the soil comes from the comminution of the rocks and there seems to be on the whole a good deal of uniformity in their composition throughout the Island.

The most numerous untried bottoms may therefore be judged by the result of the few experiments that have been made here and there. On the Tôbets, a northerly branch of the Ishcari, near the sea; on both banks of the Ishcari itself near its mouth; around Sapporo on all sides; near the mouth of the Yoichi, a large stream half way between Otarunai and Hurubira; on the Hattari a small river near Iwanai; and at the mouth of the Mombets near Usu on Volcano Bay; there are small farming settlements; and, in every case, as I understand, the soil has been found satisfactorily fertile, though probably less so than the exceptional prairies of Illinois, and under continued cultivation more in need of artificial enrichment. It is possible also that there is a lack of lime in the soil; since limestone is found in comparatively few places in Yesso. An artificial addition of lime or of gypsum would in that case be an improvement to the farms.

Around a great part of the shores of the Island, but especially on the north-east coast there are plains that may be regarded as New Alluvium or at least corresponding to it in age; but they are perhaps too sandy to be compared in fertility to a river bottom. Indeed such a plain for fifty miles or more east of Mororan is very barren; owing, however, to the special fact that it is covered with layers of pumice that have been thrown out from time to time by the Tarumai Volcano. But at a little depth there (in some places, if not everywhere, only a foot) there is a deep rich-looking black soil, the result of the growth and decay of grasses and of the decomposition of the pumice through a long period of volcanic inactivity. Possibly the shallow superficial deposit of undecomposed pumice might be in some measure removed or by very deep plowing so mixed with the underlying soil as to reclaim that wide space, which is now little better than a desert, and turn it into rich farming land.

The coast plains seem to be but ten or fifteen feet above the level of the sea, and they are perhaps "raised beaches," showing that the Island has been recently raised to that height above the level of the sea. Very often the hills behind such a plain show by the shape of their steep bluff like front that the sea once washed their feet. Looking down, however, towards sunset on such a plain from the hills east of Oshamambe, at the head of Volcano Bay, where the shore has for several miles a broad and gentle curve, a number of equally long and beautiful curves parallel to it and brought into relief by the western light may be seen, formed by ridges like huge winrows, along the plain for many scores of yards back from the sea. It is clear that such land and the now more level land behind (and it seems of about the same height as all the other coast plains of Yesso) has been formed by the action of the sea rather than of rivers or of a wholesale raising of the Island. The ridges have been raised one after another by remarkably heavy storms or stormy seasons ; and the space between has been gradually filled in and levelled up by the wind and rain and such causes. The wind as well as the waves may also have helped to raise the ridges in the first place. The space outside the newest ridge is slowly widened by the ordinary waves and tides and currents constantly bringing sand from the neighboring rocky headlands, stirring it up time and again, and gradually throwing it higher and higher upon the shore out of the future reach of the water. The level of the plain then comes to mark the highest possible action of the sea just as the level of a river bottom at length reaches the level of the highest floods. It is a striking illustration of the land forming powers of the sea, which tends to fill up the hollow parts of the coast ; at the same time that the projecting head-lands are eaten into and worn away by the waves ; both tending to give such a smoothness of outline to the coast as Yesso in general has. Such an outline has sometimes been attributed to the raising of the land ; wheerby what was just below sea level and has had its irregularities of shape somewhat concealed by the silting action of the streams along shore is brought to light and gives its roundness to the coast.

That Yesso has at no very remote period (perhaps within alluvial times) been sinking would seem to be shown by the shape of the sea bottom off the harbours of Chatsunai and Shibui half a dozen miles north of Iwanai, as shown by a hydrographic survey we had occasion to make there. The valley of a little neighboring stream seems very clearly to be continued under the sea to a depth of more than sixty feet at least. The shape of the bottom could hardly have arisen except by ordinary river action at a time when the land was at least so much higher above the sea than it is now.

The accumulated layers of the New Alluvium in the river bottoms are in general quite flat, just as they were dropped one upon another by the flooded, muddy river. They are of course made up of more or less fine particles of the rocks up stream ; the quartz grains persist as sand, the feldspar, so finely divided, decomposes and becomes clay. The formation is too recent to have become hardened into stone by pressure and the cementing action of percolating water solutions as older groups of rocks have been ; still less to have become disturbed from its horizontal position like them through the long continued contraction and sidewise pressure of the earth's crust.

Among the particles in the alluvium are many grains of magnetic iron sand that existed as crystals sprinkled through the volcanic rocks. As such grains are heavier than the much more numerous grains of quartz and feldspar, they tend to lag behind while the rest are washed forward by the water ; and so, after much washing and rewashing, gradually to gather together in layers by them selves in same favorable places. Such accumulations of the black sand are to be seem on many river shores and many sea beaches in Yesso. Most of the deposits are of insignificant extent, but some are very large and even of some economical value, especially those of Okotsunai on the south-west shore of Volcano Bay (containing apparently also titanium) and of the south-eastern end of the Island near Esan. Not only are there some of them so very recent as to lie upon the surface ; but there are others, a little older, that are now buried a few inches or feet beneath other sand.

Some such deposits of magnetic sand seem to have occurred in swampy land in the Ishcari valley, near its mouth and near Sapporo ; and, as happens in such wet places, to have gradually been turned to bog iron ore (brown hematite or limonite), like iron rust caked together in hard honeycombed masses. As the original magnetic sand deposits are seldom large, so the resulting bog ore is probably seldom of great extent. In such bog deposits it almost invariably happens that a very injurious amount of phosphorus becomes mingled with the iron.

Gold is another substance that like the iron sand tends by its great weight to gather together in certain favorable places, and in several valleys in Yesso, especially on the Toshibets and Musa River in the great southern peninsula, fine grains of gold derived from older rocks are found in the New Alluvium (as well as in the Old). But the gold is in very far smaller quantity than the iron sand, and, owing to the much greater fineness of the particles, in a very much less concentrated condition.

Peat also is found in the New Alluvium in many places, on branches of the Ishcari, as the Horumui and Toyohira, and elsewhere, as near Kobui, and forms beds of three feet, in one place (Kobui) even eight feet in thickness. It seems however to be commonly much mixed with earthy particles.

Among the products of the New Alluvium (which includes strictly not only the river bottoms but the surface soil of the hills) may be reckoned, in some sort, the vegetation it bears, and, in an economical sense, especially the trees. The timber of the Island generally speaking is not very heavy, but in some of the river bottoms is of larger size. The lower and middle parts of the Ishcari valley in particular seem to possess an unusually large share of heavy timber; but even there the amount is far less than travelling merely on the river would make you suppose. For the alluvial plain is almost wholly covered by the barren looking swamps already mentioned, which are concealed from the view of the river traveller by a fringe of trees that is only some 300 yards wide. The heavy forest, therefore, including even the upper parts of the streams outside of the plain, probably covers not more than a tenth as much as the area of the whole bottom, or sixty square miles in all.

Only one measurement of the amount of timber to the acre or mile has been made, and that, as mentioned in my report of last summer, showed about 21,000 feet of board measure to the acre or say thirteen million feet to the square mile, in a certain part of the Poronai Coal Field. Taking that roughly as an average of the good timber land of the whole Ishcari bottom (which perhaps would not be altogether too wide of the truth) there would be in the whole sixty square miles of forest something like eight hundred millions of feet of board measure. Important as that amount is, it is easy to see its utter insignificance in an economical point of view as compared with the mineral resources of Yesso. Even if the whole Island were covered with such a forest as we have been supposing it would scarcely have the value of three square miles of the coal lands near Poronai.

It is also to be borne in mind that the rapidly growing timber of moist bottom lands is usually of poorer quality than that of the mountains; and there, no doubt, is the reason of the inferiority already noticed in comparing Yesso wood with that of Nippon.

6. *Old Alluvium.*—The Old Alluvium, or Bluff Formation as it might be called, is essentially the material of ancient river bottoms, just as the New Alluvium forms the present ones. In Yesso, even the old formation is apparently yet undisturbed in the horizontal position; but the small streams by their constant wearing have hollowed its surface and the larger ones have cut their valleys deeper and left it at a higher level than the newer bottoms. Sometimes a comparatively rapid change of level in a river may have taken place through the removal of some barrier that has been worn away or possibly even by the rising of the whole land above the sea level. Such ancient bottoms are sometimes very level and are often called river terraces. They are to be found in very many of the valleys of Yesso; and have generally a steep bluff-like front.

But the surface of the Old Alluvium even when comparatively undisturbed is often very far from level, especially in short, steep valleys such as are found in many places along the sea shore, where a mass of loose earth and stones has been washed down from some narrow valley or gorge in the mountains and has spread out in fan shape upon the open space below, with a very visible slope downwards towards the sea. A fine illustration of such a deposit is seen at Iwanai; but smaller ones are extremely numerous elsewhere on the coast. The sea has commonly cut into the front of the deposits and made steep bluffs of varying height along the shore. Sometimes the height of the bluffs is pretty uniform for some hundreds of yards or even miles, though, above, the slope backward towards the hills may be very decided. To a traveller passing below such bluffs, they look somewhat like the edge of a " marine terrace;" but the flat land above has never been the beach of the sea; the level is far too various, and the mode of formation is too obvious.

There are however in Yesso a very few cases of true terraces near the sea shore, not to repeat the possible (but improbable) explanation as "raised beaches," of the low plains already mentioned as running round a great part of the coast at a height of ten or fifteen feet above the sea. At the Idzumisawa Oil Lands, a dozen miles west of Hakodate, there are three terraces, about 120 feet, 180 feet and 220 feet high, facing the sea. As terraces at corresponding heights have not been observed on other parts of the coast it is difficult to believe that these could have been old sea beaches that have been successively raised to their present height by an upward movement of the whole Island. Possibly they may mark the level of some large old lake that filled the greater part of what are now the straits between Yesso and Nippon; a lake which by the removal of barriers (either by the gradual wearing away of running water, or even by the help of volcanic action) may have stood for long periods at different heights. Near the Huurebets, (or Fuurebets) a brook on the west coast about 40 miles north of Rurumoppe, are also three or four small low terraces say 15, 25, 30 and 40 feet high but although now open to the sea, they may have been (and I suppose they were) ordinary river terraces that the sea has approached by wearing away the shore. It is therefore very probable that there are strictly speaking no marine terraces in the whole island.

The Old Alluvium may perhaps (in some parts, at least) be of the same age as the Drift (or Diluvium) of western countries; but seems nowhere in Yesso to correspond with it in mode of formation. For no traces whatever of glacial action have been found; no confused unbedded masses of mud and of small and large bowlders such as glaciers leave in their moraines; no slightly water rolled bowlders at a great distance from the mother rock; no rock surfaces polished with glacial mud and engraved with straight lines and grooves by stones caught beneath a huge mass of moving ice. It would seem that either the climate must have been too warm here during the Glacial Period; or else that the Island was at that time mainly or wholly beneath the level of the sea. It is possible, however, that in the high central mountains small glaciers even now exist and that traces of much larger ancient ones may be found.

The materials of the Old Alluvium are found then, everywhere to be bedded like those of the New Alluvium; and evidently being gathered together in the same way may therefore be expected to have in general the same composition and the same properties and to contain the same exceptional substances. The surface indeed is different for farming purposes, in that it is higher and drier; and on the slopes the soil that is enriched by decaying vegetable matter may be of less depth because it is always tending to slide downward into the valleys, forming part of the New Alluvium. There is however a great amount of such good cultivable uplands; and they are to be found in more or less wide strips bordering the low bottom lands and sometime are of great extent. The valley of the Tokachi and its branches (for example, the Otopchi on the north-east) contains a large amount of such rich uplands covered with a luxuriant growth of tall grass, a fine region now for cattle grazing and hereafter for grain raising. The Kusuri valley and the eastern end of the

Island has apparently much more of Old Alluvial land; and a certain extent of it is found on the borders of the Ishcari valley, in the Iwanai valley and the upper part of the Shiribets valley and in many others.

Of the minerals contained exceptionally in the Old Alluvium, gold is the most important; and the occasion and mode of its occurrence are the same as in the case of the New Alluvium already mentioned; except that, as the grains of the old deposits have been somewhat less washed and rolled about they may in general be somewhat larger, and on the other hand in respect of numbers perhaps less concentrated. The largest quantity of such gold (sprinkled to be sure through too large a mass of gravel) seems to be in the Toshibets valley of the west coast over against Volcano Bay ; and there is another large one in the Musa valley a dozen miles north-east of Matsmai.

Of iron sand or of bog ore no noteworthy deposits have been observed in the Old Alluvium; and none of peat have been seen. The fibrous lignite that was supposed three years ago to come from the Old Alluvium probably comes wholly from the Toshibets Group.

c. *New Volcanic Rocks.*—The New Volcanic Rocks correspond in respect to age with the New and Old Alluviums and perhaps with part of the Toshibets Group; for the volcanic action may have been going on ever since the time of the Old Volcanic Rocks, and in some places may have remained undisturbed since the time of the Toshibets Group. Nevertheless there is a striking difference in appearance between the older commonly more compact, steeply dipping volcanic rocks and the newer, often cellular, essentially level bedded ones.

The thickest masses of New Volcanic Rocks that we have found in Yesso have been on the upper Ishcari and the upper part of the Otopchi valley where there are light buff cliffs of soft rough (probably trachytic) volcanic rock, up to perhaps 200 feet in height, and they appear to have come from Ishcaridake and Tokachidake ; but it is possible that these should rather be reckoned among the Old Volcanic rocks. There are also New Volcanic rocks of unknown thickness upon and near all the volcanic mountains, already mentioned in the general description of the topography of the Island.

Two of them, Tarumai and Komangadake, have within historic times had violent eruptions of pumice, and others are still sending out sulphur fumes. The latest eruption was that of Tarumai, which lasted from noon of the 8th of February, 1874, until the next noon, but was chiefly active from five in the evening until two in the morning. About three tenths of a foot of light brown pebbles of pumice of the size of a filbert were scattered over the ground within the space of a few miles. The same volcano had a small eruption of pumice about the first of March 1867, and a large one seventy years before that. Komangadake also had a large pumice eruption on the 23rd of September, 1856, in which some seventeen lives were lost in neighboring villages. The relatives of some of the deceased, although (in 1873) remembering the event very well, knew nothing of any eruption of hot water along with the pumice. Traces of pumice are also found that probably came from other volcanoes in the pan-handle peninsula ; but some, now somewhat altered (as, for example, at Otarunai), probably belong rather to the Old Volcanic Rocks. The new pumice seems everywhere to be nearly of the same light brown color, to have capillary pores (therefore of rhyolitic composition) and to contain numerous small hornblende crystals.

Of the volcanoes that send forth sulphurous smoke at present there are besides Tarumai and Komangadake, seven, or in all nine ; namely, Esan, Usu, Iwaonobori, Nuburibots, Meakan (?), Itashibeoni, and, it is said, Riishiri.

The smoke condenses to some degree on the comparatively cool ground and leaves deposits of sulphur; especially at Esan, Tarumai, Iwaonobori, Nuburibets and Itashibeoni. At Itashibeoni the sulphur (as it appears to be) may be seen violently boiling in a hole or small crater 15 or 20 feet in diameter and of unknown depth.

Other deposits of sulphur that occur come from the waters of hot springs, and may perhaps better be classed with the New Volcanic rocks than with the Alluvium; for although it corresponds in age with both, yet in origin, issuing from the earth below, it corresponds rather with the volcanic rocks, and such springs occur chiefly, perhaps wholly, in the neighborhood of new or old volcanoes. The largest of those deposits are near Kobui, a few miles south of Esan; and they are of gray sulphur. A very little yellow sulphur is also found near the Nigorikawa hot spring near the south-west shore of Volcano Bay. Other hot springs form deposits of other substances, silicious, for example; which may also be classed for the same reasons with the New Volcanic rocks.

Shiribetsudake, although it has never been known to make eruptions within historic times, yet has still so fresh a conical shape that it may be reckoned a new volcano even without our having yet observed any level bedded volcanic rocks in its neighborhood. Yubaridake has also been conjectured to be a volcano, not yet very ancient; but it has not been approached near enough to speak with much positiveness about it. Hakodate mountain might perhaps be classed along with the new volcanoes; but its shape is already much deformed, though the old crater can apparently still be made out.

d. Toshibets Group.—The Toshibets Group has been studied chiefly on the Toshibets and Musa rivers in the great southern peninsula; but is found in several other parts of Yesso, both at Idzumisawa, Washinoki, Yamukushinai and many other places in that peninsula and in the main body of the Island near Atsuta (a few leagues north of Ishcari), near the Poronai and Ichikishiri coal surveys, on the middle Ishcari below Kamoikotan, and along the south-east coast near the Tokachi river. On the north-west coast near Huurebets it was thought to exist, but one of the fossils found there is also found in the Horumui Group, and as there is much resemblance between the rocks of the two groups one may have been mistaken for the other. Further south on that coast, near Herashibets, the rock beds are undoubtedly of the Horumui Group ; and there seems to be no change in the rocks from there northward to Huurebets. It is, however, possible that the two groups are there conformable and pass gradually one into the other.

Although there is sometimes so much resemblance between the rocks of the two groups, they may be distinguished by some of their contents besides the fossil remains of animals. For example, the Toshibets rocks contain oil, as at Washinoki, Yamukushinai, Idzumisawa, Atsuta (traces) ; and no thorough coal but fibrous, woody lignite, as at Tomigawa, across the harbor from Hakodate, at Kemushitomari (south-east of Volcano Bay), at Torizaki (near Washinoki), on the Tokachi a few miles above its mouth, on the middle Ishcari and elsewhere. On the other hand, the Horumui Group has apparently no fibrous lignite (except possibly small traces near Herashibets), but coal, strictly brown coal, yet black and shining like bituminous coal ; and, so far as known, has no oil. The sand rocks of the Horumui Group are also generally rather harder and firmer than those of the Toshibets Group.

In the Toshibets and Musa gold surveys Mr. Munroe distinguished two divisions of the Toshibets Group ; the upper of which he called the Toshibets Clay Rocks and the lower, the Chingkombe shales and sandstones and on the Toshibets itself he thought he perceived an unconformity between the two, though there was none elsewhere. The two portions must, however, differ extremely little in age. He gives the following section from above downward of the Clay Rocks of the Toshibets valley :—

a.	Sandy clay rock ; usually bluish gray, weathering yellow, with thin beds of brown sand stone in lower thirty feet		425 ft.
b.	Sandy clay rock, like the above ; containing fossil shells and thin layers of lignite. (This seems to be the only bed in the whole section, in which fossil shells occur in any quantity)	125 ft.	148 ft.
ba.	Sandstone, very fine, olive green ; passing into a clay rock	10-20 ft.	
c.	Sandstone, hard and coarse, passing into a conglomerate sometimes fossiliferous		45 ft.
d.	Clay rocks, massive, without laminæ or bedding planes ; upper portion concealed ? usually olive green		310 ft.
e.	Brown sandstone, containing large fragments of clay rock ; quite soft		162 ft.
f.	Olive green sandstone, very fine and soft; with thin beds of brown sandstone at bottom		184 ft.
g.	White sandstone, (pumice tufa ?) with thin beds of olive green sandstone		40 ft.
h.	Pumice conglomerate, with thin beds of brown sandstone		67 ft.
i.	Olive green sandstone, fine (sandy clay rock ?)		20 ft.
j.	Pumice conglomerate, bluish weathering reddish		8 ft.
k.	Olive green sandstone, fine (sandy clay rock ?) with beds of red sandstone		103 ft.
l.	Brown sandy conglomerate		20 ft.

m.—Olive green sandy clay rock, weathering yellow; in thick beds	80 ft.
n.—Pumice conglomerate	15 ft.
o.—Olive green shaly sandstone	248 ft.
p.—Black loamy (?) sand	2 ft.
q.—Olive green sandstone, with several layers of red sandstone 1½ ft. thick	20 ft.
r.—Olive green sandstone (clay rock ?)	110 ft.
s.—Conglomerate, containing large fragments of clay rock	10 ft.
t.—Olive green clay rock	37 ft.
u.—Soft brown sandstone	22 ft.
v.—Brown sandstone, containing large fragments of clay rock	12 ft.
w.—Brown sandstone, becoming a conglomerate near the bottom, mostly concealed, more than	236 ft.
x.—Olive green clay rock, &c., (not measured)	—
Total thickness measured	2,174 ft.

The materials of the "clay rocks" seem to have come, he says, wholly from volcanic rocks. The porous nature of the grains of pumice in many of the beds is readily seen with a lens, and the pumice is easily fusible. In the tufa and the pebble rocks there are also rounded grains of dark blue stone, sometimes almost black, easily fusible to a black bead. The sand rocks are made up of rounded grains of the same blue stone with small grains of quartz and feldspar (?), usually cemented by a very fine white pumice like sand, with occasional grains of pumice; and are readily fusible except the quartz grains. The clays are all more or less fusible; some of them easily melt to a dark colored glass. The sand rocks and tufas contain a notable amount of magnetic iron sand; also derived no doubt from the volcanic rocks.

On the Musa River he supposes the following section of the Clay Rocks to exist (from above downwards):

Olive green clay rock, more or less sandy	82 ft.
Concealed	46 ft.
Olive green clay rock, soft, containing small bivalve shells	34 ft.
Olive green sandy rock, with concretions of limestone	160 ft.
Concealed	56 ft.
Olive green clay rock ; soft, weathering red ; with serpulæ	58 ft.
Same, with concretions of drab limestone, and serpulæ	25 ft.
Same rock, without concretions	75 ft.
Olive green sandstone, very fine, quite hard, (with concretions ?)	50 ft.
Olive green clay rock	85 ft.
Greenish gray sandstone, sometimes nearly white with few concretions.	180 ft.
Olive green sandy clay rock, soft, with fossil shells and serpulæ	95 ft.
Concealed, mostly olive green sandy clay rock, weathering quite yellow	262 ft.
Greenish gray clay rock, soft	25 ft.
Dark olive green sandstone, fine	30 ft.
Olive green clay rock	45 ft.
Dark olive green sandstone, fine	105 ft.
Concealed	66 ft.
Olive green clay rock, with fossils, and concretions of limestone	54 ft.
Total	1533 ft.

The rocks of the section closely resemble those of the Toshibets section. They are very soft, and nearly all stick to the tongue and become plastic when moistened. There are no beds here of tufa nor of coarse sand rock ; but all seem to be fusible (except the quartz grains), especially the more plastic clays; and all are probably made up of volcanic material.

Of the Chingkombe shales and sandstones he gives the following section near the Chingkombe river of the Toshibets Gold Field (from above downwards):

a.—Red shales, olive green shales weathering dark red. Large concretions of bluish limestone very abundant	410 to 540 ft.
b.—Soft sandstones? (concealed); with beds of compact white pumice rock very fine grained	140 ft.
c.—Green sandstones, fine and coarse, usually quite hard. Near the bottom, one bed of fine pumice tufa	477 ft.
d.—Lower strata concealed	...
Total thickness measured	1,157 ft.

The characteristic red shale "*a*" is fusible with difficulty. It is hard, solid, usually olive green weathering dark red, and has a peculiar, subconchoidal and cubical cleavage; so that the rock falls in weathering into rectangular fragments with rounded dark red faces an inch and a half or two inches across. No fossils, except serpulæ, were found either in the shale or in its limestone. The tufa "*b*" is unlike the pumice tufas of the upper Clay Rocks; it is fine grained white, very light, but compact and solid, resembling kaolin, and is easily fusible to a colorless glass. The sand rock "*c*," commonly bright green, seems to be made up of rounded grains of quartz, feldspar and mica with fragments of a dark blue metamorphic or volcanic rock and with a fine pumice cement; and is partially fusible, particularly the pumice.

Below the Toshibets gold field on the same river he found the red shales to have a thickness of some 1,350 feet. Within their upper fifty feet there were several beds of white pumice from six to ten feet thick. Below the shales was a coarse sandy pebble rock.

In the Musa Gold Field he gives the following section of the Chingkombe shales (from above downwards):

Hard sandy shales, olive green to gray, weathering dark red, and having a cubical cleavage........	175 ft.
Hard olive green shale, less silicious, but similar to the above..	270 ft.
Concealed (mostly shale ?)................................	85 ft.
Hard olive green shale (as above)......................	25 ft.
Greenish gray laminated shale, with occasional beds of limestone, partly concealed......................	500 ft.
Conglomerate, and coarse sand rock..................	50 ft.
Total..........	1,105 ft.

The upper beds are much like those of the Toshibets section; but the lower break into thin plates instead of cubical blocks. The rocks of the section are much harder than those of the Clay Rocks above; and seem to be less made up of volcanic material. The coarse sand rock at the bottom seems to be derived from metamorphic rock slates and quartzites, sometimes with a tufaceous cement.

On the Horumui near the Ichikishiri survey the rocks of the Toshibets Group contain many pebbles of crystalline rocks, such as (rhyolitic ?) syenite, which I take to belong to the group of Old Volcanic rocks.

The soft thick beds of sand rock near Atsuta show high up in the sea cliffs large, round (six ? foot) masses of harder rock here and there which look a little as if they might have been dropped from floating ice at the time that the sand was originally deposited; but from the uniformity of their size, shape and appearance may perhaps rather be of concretionary nature.

The presence of the Toshibets Group near most of the principal gold fields of Yesso is rather striking. It seems to be absent however from the little and poor Esashi gold field and from the still poorer, small fields on the southern shore near Urakawa; but in either case may possibly be found to exist not very far inland, or to have once occupied some of those valleys which seems now deprived of it. There is no probability that the gold originated in the Toshibets rocks; but it is not unlikely that it may have been to some degree concentrated in them, after having been derived along with the other materials of the rocks from some older formation. The fact that those other materials seem exclusively to have come from Old Volcanic Rocks strongly favors the conjecture that the gold also came from them. The presence of the grains of magnetic iron sand in the Toshibets rocks is a precisely parallel case. The apparent existence of gold in those rocks recalls to mind the gold washings on the Indus which are supplied from "Old Alluvial" beds, older than our Yesso Old Alluvium and perhaps not much newer than the Toshibets Group.

The direction of the axes of the rock folds of the Toshibets Group is on the Toshibets, on the Musa, at Washinoki, at Idzumisawa, on the Horumui, on the Ikushibets near Poronaibuto, in short almost, or quite, everywhere that observations have been made, nearly north and south, though varying apparently at different places some ten or fifteen degrees or even more from true north, especially towards the west. They appear to have been folded by a later movement than the north-easterly and south-westerly one which chiefly disturbed the Horumui Group, and which does not appear to have affected the Toshibets Group anywhere. The Horumui Group on the other hand shows traces of the north and south system also.

In the bed "*b*" of the Toshibets section there are many fossil shells (Pectens, oysters and others) of a very recent look; and small shells and worm casts were met with elsewhere, particularly in the upper part of the section. The fossils have not yet been studied, and it is doubtful whether those yet observed would enable the age of the

Group to be determined with any precision; and especially the living shells of the surrounding seas are perhaps not yet well enough known, to make a percentage comparison of extinct species possible. I have very roughly conjectured that the Group might be of Middle Tertiary age. The extremely disturbed condition of the rocks, with dips about vertical through some wide spaces, seem to make it hardly likely that they should be newer than that. Lithologically there is a good deal of general resemblance in the sand rocks of the group to the mollasse of Switzerland.

e. Old Volcanic Rocks.—A very large part of the Island seems to be made up of Old Volcanic Rocks; particularly the whole north-eastern side and almost the whole of the panhandle peninsula. They seem also to be the rocks of the southern end of Sagalin and of the island of Rebunshiri close by Riishiri and perhaps make up the north end of Nippon. In some places such rocks issued perhaps from volcanoes that still send out new volcanic rocks or that apparently, like Shiribetsudake, have not long ceased to do so. In other places, as near Hakodate, traces, of old craters may yet be seen. But it is not improbable that much of these widely bedded rocks came from massive eruptions out of large fissures. For my own part, I have not met with a single case where such rocks appeared unmistakably to fill a fissure forming a dike; though several instances are mentioned by Mr. Munroe and other observers, possibly owing to the fact that their work has been more on the border of the volcanic rocks where the junction between them and older rocks, sometimes perhaps those of the Toshibets Group, may be more visible.

The Old Volcanic rocks, however are commonly very distinctly bedded, although their dip, sometimes comparatively gentle, sometimes steep, is often obscured by cleavage planes. The dips are in very various directions, and it seems impossible, even more than for the sedimentary rock groups, to make out for them any simple system of parallel axes. Near Iwanai a north-east and south-west system seemed to prevail, making the rocks perhaps conformable to the underlying Coal bearing group ; and such a system would correspond well with the bearing of the two nearer and larger Kuril Islands as well as of that group in general, with the Nemoro and Itashibeoni peninsulas, and with the possible alignment of many of the new volcanoes, as already mentioned. But, on the other hand, the north end of Yesso and Sagalin seem to be of the same old volcanic group, and to be arranged quite as unmistakably in a system of north and south folds ; a system that, as already shown, seems particularly to affect the rocks of the Toshibets group, and, as will be seen, to be impressed though in a less degree upon the coal bearing rocks. It seems therefore probable that both systems of folding took place after the laying down of the Old Volcanic rocks, and that those rocks are in some regions especially folded according to the other system, and perhaps in still others both are in a measure combined or alternated within short distances, as has been more thoroughly studied out in regard to the coal bearing rocks. It also seems very likely that the Old Volcanic rocks may have had (as newer volcanic rocks so often have) local dips, in directions away from the centres of eruption, which combined with either one or both of the more regular and more wide spread systems of folding would give rise to great apparent irregularity and confusion of the dips of the whole group.

The Old Volcanic rocks of Yesso seem to be almost (in my opinion, quite) without exception of what used to be called trachytic character, almost always trachytic porphyries, or apparently what Richthofen calls rhyolite, with small imbedded crystals of glassy feldspar (taken to be sanidin.) The sanidin crystals seem, however, in some places to be partially decomposed so as to have become locally of an opake white color. Hornblende also is a very common ingredient, perhaps an almost invariable one, even in the most compact, porphyritic kinds (as in the case of the newer pumice); but sometimes it may be replaced by pyroxene. Some of the more compact kinds seem to have been mistaken at times on a cursory view for ancient eruptive rocks; but, even if their trachytic, or rhyolitic character be sometimes locally a little obscured, their invariable association with unmistakable trachytic or rhyolitic rocks proves them to be of comparatively late date. One of the most striking cases of resemblance to ancient rocks is a certain light gray, coarse grained syenite found on the sea shore at several places near Chikabutomuushi on the northern part of the north-east coast. The syenite though of a fresh look seemed at first glance a very fully characteristic one, with milk white feldspar, but with crystals of glassy quartz and a distinct feldspathic paste, blackish hornblende and a little blackish mica answering well to Richthofen's description of granitic rhyolite and it formed at one place a synclinal conformable to trachytic or rhyolitic rocks within a few yards of it. Further north similar syenite alternates with trachytic porphyry; and all the rocks of that shore seem clearly to be of the same class. Undoubtedly, the closely similar syenitic pebbles, (and exposures?) of the Toshibets belong to the same age. Some fresh looking green syenite brought by Mr. Munroe from the south-western coast belongs also to the Old Volcanic Group in my opinion. There are a few cases in the southern part of the island where diorite, supposed to be ancient, and perhaps certain other ancient rocks have been reported to exist, all of which, however, except the metamorphic and perhaps granitic rocks of the Kamoikotan Group I take to belong to the group of Old Volcanic rocks with which they are intimately associated and commonly quite surrounded.

The color of the trachytic or rhyolitic porphyry is probably oftenest a dark gray, sometimes becoming very dark, now and then blackish in fine grained varieties; but is often light gray and sometimes reddish, more rarely light brown and buff. The beds are sometimes tufaceous, and then often greenish, and sometimes very fine grained, as at the northern end of the Island. Sometimes, as at the Shibets hot springs, south of Sharidake, the trachytic or rhyolitic tufa is a compact pebble rock of a very bright green color when freshly broken ; and perhaps somewhat similar rocks have elsewhere been taken for diorite. Many of the tufa beds have pebbles of great size, a foot or even three feet in diameter, as on the coast north of Iwanai, and between Shari and Itashibeoni, and in many other places. The large pebbles north of Iwanai are sometimes black with distinctly seen crystals of glassy feldspar ; they are imbedded in greenish gray feldspathic sand. Indeed some of the beds of the little adjacent coal field of Kayanoma seem to be sand rock, made up of feldspathic grains, minute fragments of some volcanic rock, and so perhaps ought strictly to be called tufaceous, though purely sedimentary and not deposited from any volcanic floods. Perhaps also many of the tufa beds are equally removed from any volcanic action. Sometimes in tufa rocks, as at Yoichi, at the Shibets springs and elsewhere, there are fragments of obsidian. Near Motoenep a few leagues south of Chikabutomuushi there seems to be some pearlite like pitchstone, perhaps likewise in tufa pebble rock. At Otarunai and at several other places in the south end of the Island there is old and pretty compact, very white pumice ; and in some places it has become partially decomposed, so as to resemble kaolin, and perhaps also from similarity of grain and composition deserves to be called so; although it is not plastic, in spite of having the smell of clay when moistened with the breath.

In a number of places the rock has a columnar structure with close grained compact texture and very dark gray color, as on the coast between Otarunai and Ishcari, between Shikabe and Kakumi (south-east of Volcano Bay); at Awashiri (about ten leagues east of Shari on the north-east coast); between Shari and Itashibeoni, at a point fifteen or twenty miles north of Iwanai; and probably at other places. At all those places, however, the rock seems unquestionably not to be basalt, which it resembles in its columnar form; but where closely examined has been found to contain glassy feldspar, and no doubt everywhere else also is merely a modification of the trachytic porphyries (rhyolite) which surround it. The distinguishing element of basalt, olivine, has not been found in any rock in Yesso, although some of the columnar rock near Otarunai contains small yellowish brown crystalline grains which are probably amphibole, or possibly pyroxene, corresponding to the similar crystalline grains that are found in so many of the rocks of Yesso that otherwise answer so precisely to the characteristics of trachytic porphyry (rhyolite). Mr. Munroe has noted the presence of basalt at some points which I have not visited in the southern end of the Island; but has judged by its color, texture, columnar structure and general appearance without yet finding any olivine.

In the upper part of the Ishcari valley there are many very dark or blackish rocks that I took to be a part of the blackish quartzites (of the Kamoikotan Group) that fill a great space there. The opinion was possibly too hasty, and a more careful examination may perhaps show that a large portion of what I have marked on the map as taken up by the Kamoikotan Group should have been marked as

Old Volcanic ; enlarging thereby still more the field of those rocks already so very large.

There are some metallic ores such as those of lead (galena), zinc (blende), manganese (carbonate and psilomelane) and copper pyrites which occur in thin veins in the Old Volcanic rocks, as on the Horobets (near Mororan), near Jôzankei (above Sapporo), at Kimpozan (near the Kayanoma Coal Mines), at Sakkadzuki (a league or two north-west of Kayanoma), at Kudoö, Yurap, Ichinowatari and perhaps other places. With the lead there is a little silver. Iron pyrites is commonly associated with the ores and at Jôzankei there is a little orpiment. It seems probable that the veins were filled by substances dissolved by water out of the rocks adjoining the fissures and that the metals are therefore originally of Old Volcanic age. Some of the veins, as at Ichinowatari, and possibly at Yurap, seem to cut also across rocks of the Kamoikotan Group ; but, if I mistake not, none of them fail to cut in part at least across closely adjacent Old Volcanic rocks. In every case, therefore, the metals may have come from the volcanic group ; and it seems more probable that the same group of metallic ores in so many different places should have had a like origin and should have existed originally in the Old Volcanic rocks alone, to which in the great majority of cases they appear at any rate to be confined. It would seem also not impossible that the gold of the alluvium may have come in the first place from the same metallic veins of the Old Volcanic rocks, which are in almost every case near by ; though Mr. Munroe, who was specially charged with the gold surveys, thinks that it originated in the old metamorphic rocks which I have placed together in the Kamoikotan Group, rocks which are also nearly always not far distant but in a few cases seem to be remarkably so. I may add that what I have seen this summer in Nippon leads me strongly to suspect that the rocks of the gold mines of the neighboring island of Sado are of the same Old Volcanic Group.*

f. Horumui Group.—The Horumui or Brown Coal Bearing Group seems to fill a broad strip from north to south, bending a little towards the west, from the lower Teshio valley to a point four leagues south-west of Urakawa ; but in crossing the main valley of the Ishcari is concealed by the alluvium for a little space. Another but much smaller patch of the Group reaches along the south-west coast from Kusuri past Akkeshi to near Nemoro and to an unknown distance inland ; and there are still very much smaller spots of it at Kayanoma (near Iwanai), and at Kudoö, and its opposite island of Okushiri. These two last and nearly the whole of the Akkeshi field and probably some large portions of the main field, especially its outskirts, are quite unproductive of workable coal. Nevertheless, the extent of the productive coal fields appears to be more than 5,000 square miles, or about 850 square ri (one sixth of the whole Island), including a hundred square miles near Kusuri and perhaps only three square miles at Kayanoma. The Kayanoma coal field although so far detached from the main one has a series of coal beds and of other rocks that bears a strong resemblance to the section of the more productive part of the main field ; and there is also great resemblance in the coal and in the geological structure of the field; so that even though there has yet been proved to be no correspondence in the fossils (for which there are hitherto scarcely any materials), there can be no doubt as to their corresponding age. Nor indeed can there be any such doubt either in regard to the correspondence in age of the other fields, although closely agreeing sections are there still lacking. As to what the age of the Group may be in comparison with the well studied geological formations of western countries nothing very precise can yet be said. The fossils that are to determine the relative age of the rocks have not yet been collected in any large number, and the few that have been gathered have not been carefully studied. My impression has been, as already mentioned in reports, two years and a half ago and again over a year ago, that the Group was of early Tertiary or possibly of late Secondary age. Some two or three months ago a few fossils were brought to me from the southernmost end of the Main Coal Field, and also probably its lowest rocks, perhaps some distance below all the coal beds; and among the fossils was a ptychoceras, which is reckoned as a Cretaceous (late secondary) fossil; and there are fossil ammonites found also in the same neighborhood, a confirmatory fact. It is probable therefore that these lower beds at least are Cretaceous; possibly the upper part of the great thickness of coal bearing rocks may reach into the Tertiary.

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* This opinion has lately been fully confirmed by a specimen of the rock crossed by the Sado gold bearing vein. It seems very clear that all the metallic veins of Yesso as well as of Shinano, Echigo, Sado and perhaps all the rest of Japan traverse Old Volcanic rocks ; though in two or three cases the veins traverse old metamorphic rocks in addition. The probability, then, is very strong that the metallic ores and the gold all came from the Old Volcanic rocks. The fact is important in Yesso ; for a very large part of the Island, that is not yet minutely explored (except by the savages), is made up of such volcanic rocks, and may yet be found to contain workable ore veins. The only volcanic region in Yesso that is well known is the south-western end of the Island ; and, as already shown, it has been found to contain a large number of metallic veins, though, as it happens there, they are all too poor to work.—27th February, 1877.—B. S. L.

The geological and topographical maps of our connected surveys at Poronai, Nuppaomanai and on the Upper Bibai, Sankebibai and Naie rivers, have enabled us to make out the following section (from above downwards) through a thickness of 6,435 feet, including probably all the workable coal beds, as well as nearly all the unworkable ones, and a great number of the other beds of rocks; and showing the relative position of the beds with the probability of a good deal of exactness on the whole ; for, although the surveys were rough ones, almost every part of the general section has been confirmed by smaller sections and measurements in two or more places :

		Feet.
Good *coal,* (B 685 a)		1.79
Unknown		15.00
Coal traces, (B 682 l)		—
Unknown		30.00
Coal traces, (B 682 k)		—
Unknown		35.00
Good *coal*	0.35	
Soft poor *coal*	0.15	
Good *coal* (B 670 r)	1.50	
Soft poor *coal*	0.20	
Coal slate	2.00	
Coal	0.15—	4.35
Unknown		55.00
Coal traces, (B 682 i)		—
Unknown		480.00
Greenish gray sand rock, (B 669 l) with fossils (clams), perhaps		2.50
Unknown		145.00
Hard grayish brown clay (Y 417 ma), exposed perhaps		3.00
Unknown		270.00
Sand rock, exposed perhaps		3.00
Coal		2.80
Unknown		110.00
Greenish white micaceous sand rock		3.00
Weathered brown sand rock		6.00
Flinty shale containing clay and lime, (K 942 l)		7.00
Unknown		7.00
Bluish gray sand rock, weathering brown, (U 358 i), exposed perhaps		3.00

		Feet.
Unknown		34.00
Bluish gray sand rock weathering brown		1.80
Coal (K 745 ia)		1.70
Coal slate		0.50
Grayish brown soft clay		1.30
Light gray soft clay with a little *coal*		0.80
Unknown		130.00
Light gray coarse sand rock		2.00
Good COAL, (Y 411 gb), PORONAI No. VII	1.40	
Bony *coal*	0.90	
Poor *coal*	1.40	
Coal mixed with gray clay	1.80—	5.50
(At (K 746 b) the same bed has 6.60 of "good COAL").		
Coaly clay		0.80
Unknown		14.00
Grayish white shale, (K 947 q), exposed perhaps		2.00
Unknown		8.00
Yellowish white sand rock (K 948 z), exposed perhaps		2.00
Unknown		25.00
Grayish white shale, (K 947 z), exposed perhaps		2.00
Unknown		20.00
Yellowish white fine sand rock (K 948 v) exposed perhaps		2.00
Greenish gray shaly sand rock weathering brown		8.00
Bean size pebble rock with white pebbles and with a 0.5 seam of black coal slate in the middle		0.30
Coal slate		0.20
Same pebble rock		1.00
Unknown		0.80
Coal (L 577 fa), exposed		0.50
Unknown		29.00
Gray sand rock with fine black specks, weathering brown, exposed about		8.00

		Feet.
Bony *coal*	0.05	
Good COAL (L 576 i), PORONAI No. VI	4.20	
Bony *coal*	0.05	
Black clay	0.10	
Bony *coal*	0.50	
Rotten *coal*	0.10—	5.00
Good bluish gray soft fire clay		1.50
Unknown		86.50
Irregular bed of *coal* (L 576 m)		0.80
Unknown		42.00
Greenish gray sand rock weathering brown, exposed perhaps		8.00
Gray shales, rather soft		1.00
Soft *coal*	0.60	
Bony and soft coal mixed	0.25	
Good *coal* with 0.02 of slate at 0.35 from the top (L 581 p)	1.00	
Black coal slate with a very little *coal*	0.50	
Blackish soft shales dark gray at top	1.00	
Bony coal	0.60—	3.95
Gray soft shales		3.00
Greenish gray sand rock, weathering brown, exposed perhaps		8.00
Unknown		1.50
Rotten coal (L 606 pb) about		1.00
Unknown		73.00
Hard dark gray shales		0,20
Coal (L 606 oa)		0.50
Hard dark gray shales		0.20
Unknown		13.00
Blackish shales with 0.10 of poor *coal* in the middle and 0.20 of same at bottom (L 604 kc)		2.00
Dark gray shales, exposed about		0.30
Unknown		30.00

		Feet.
Coal quite hard (L 581 qa)	1.00	
Black slate	0.02	
Very hard *coal*	0.40—	1.40
Dark gray clay		0.20
Dark gray shale bluish at top, exposed		0.30
Unknown		13.50
Dark gray and blackish clays		1.20
Crushed *coal*	0.90	
Dark gray and blackish shales	0.50	
Coal, poor, or crushed (L 604 ka)	0.95—	2.35
Black coal slate		0.85
Hard gray sandy shales, exposed		1.00
Unknown		50.00
Blackish coal slate		0.50
Coal	0.75	
Dark gray shale	0.65	
Coal	0.80—	2.20
Blackish coal slate		0.05
Greenish-gray sand rock, dark at top		0.70
Unknown, about		4.00
Greenish gray sand rock weathering brown, about.		1.00
Dark gray and black coal slate		3.40
Coal, poor, soft and tender	0.45	
Dark coal slate	0.40	
Good firm COAL (L 602 cb), PORONAI No. V	1.70	
Dark gray and black coal slate	0.45	
Poor *coal,* tender	0.40	
Good firm COAL	1.50	
Dark shale	0.10	
Good firm COAL	1.60	
Hard blackish coal slate and *coal* mixed	0.30	
Very hard COAL	0.65—	7.55
Blackish coal slate		0.20
Soft blackish clay		0.30

		Feet.
Light gray clay shale, exposed		0.50
Unknown		19.00
Brown weathered shale, exposed about		2.00
Black coal slate		0.15
Coal, bony	0.65	
Blackish coal slate	1.20	
Coal	0.10	
Blackish coal slate	0.30	
Coal	0.25	
Blackish coal slate	0.05	
Coal	0.05—	2.60
Hard greenish gray sand rock weathering brown		0.70
Blackish coal slate, perhaps thin streaks of coal		1.85
Hard dark gray sand rock		1.30
Dark, mostly black, coaly shale		4.70
Coal		0.30
Greenish gray sand rock, weathering brown		1.20
COAL	1.60	
Black coal slate	3.20	
COAL (L 602 ba), PORONAI No. IV	5.00—	9.80
Black coal slate, hard		1.50
Unknown		100.00
Coal (L 586 r)		1.66
Dark gray hard shale		0.20
Unknown		50.00
Greenish sand rock weathering brown		2.50
Black coal slate, hard		0.20
COAL very firm (L 586 ta), PORONAI No. III		4.00
Dark hard shale		0.05
Unknown		16.00
Greenish gray sand rock		0.80
Black or bluish hard coal slate		2.30
Coal	0.45	
Blackish hard coal slate	1.50	

		Feet.
Coal	0.15—	2.10
Black coal slate, hard		0.65
Blackish gray shales, hard		1.25
Black coal slate, hard, with trace of *coal*		0.30
Dark gray shales		0.50
Unknown		53.00
COAL very firm (L 587 ba), PORONAI No. II	3.00	
Black coal slate, hard, perhaps partly *coal*	0.35	
COAL	0.20—	3.55
Clay soft, exposed perhaps		0.10
Unknown		20.00
Coal, possibly in very small part bony, (L 587 bb)		2.80
Gray shales, exposed about		0.20
Unknown		25.00
Coaly brown rock		0.20
Coal slate		0.30
Coal (Q 128 l)		0.70
Blackish gray clay		0.40
Unknown		10.00
Coal (L 587 da)		0.55
Black slate		0.10
Unknown		3.00
Dark gray shale, about		0.50
Black slate (L 587 d)		1.60
Dark gray shales, about		0.70
Black slate, perhaps		0.30
Unknown		9.00
COAL (T 145 a), PORONAI No. I	2.00	
Dark blackish coal slate, hard	1.20	
COAL	0.15	
Black coal slate, hard	0.30	
COAL	0.15	
Black coal slate	0.05	
COAL very hard	1.65—	5.50

		Feet.
Dark gray hard shales, blackish on the surface, about		0.50
Unknown		12.00
Greenish gray sand rock, exposed perhaps		1.00
Unknown		3.00
Greenish gray sand rock, exposed perhaps		1.00
Unknown		17.50
Sandstone, (Y 634 m), exposed perhaps		1.50
Unknown		25.00
Soft sand rock, exposed perhaps		1.00
Bad coal (Q 440 d)		0.15
Hard dark gray clay, exposed perhaps		2.50
Unknown		30.00
Sandstone, (Y 634 n) exposed perhaps		2.50
Unknown		240.00
Sand rock	?	
Gray clay	?	
Poor coal, (Q 438 g)	1.50	
Coal slate	?—	4.75
Unknown		108.00
Bluish gray shale, exposed perhaps		8.00
Coal slate (B 952 h)		3.00
Unknown		13.00
Bluish gray shale, exposed perhaps		6.00
Bituminous clay		1.00
Good *coal*	0.20	
Coal slate	2.00	
Good *coal*	0.10—	2.30
Coal slate		0.80
Bluish gray shale, perhaps		18.00
Coal slate, perhaps		3.00
Hard greenish gray sand rock		5.50
Bluish grey shale		13.00
Bituminous clay		1.00

		Feet.
Good **coal**, (B 952 i)..		0.70
Coal slate		0.80
Bluish gray shale perhaps		6.00
Sand rock, exposed perhaps		10.00
Unknown		11.00
Bluish gray shale, exposed perhaps		6.00
Bad coal (Y 721 c)		2.00
Bluish gray shaly sand rock, exposed perhaps		6.00
Unknown		3.50
Soft clay, exposed perhaps		2.50
Hard *coal* mixed with a little clay	0.35	
Soft clay	0.20	
Good *coal* (U 507 1)	0.70—	1.25
Gray shales, exposed perhaps		2.50
Unknown		180.00
Coal, (E 406 ab)		0.35
Light bluish sand rock, exposed perhaps		2.50
Unknown		35.00
Good *coal*	0.25	
Sandy rock	0.15	
Bad *coal* (B 869 bb)	0.35—	0.75
Coal slate		0.35
Unknown		28.00
Hard brown sand rock		2.00
Rather hard brown sandy clay		2.00
Reddish brown bad *coal*	0.30—	
Soft gray clay	0.10	
Coal	0.10	
Soft gray clay	0.30	
Coal	0.10	
Reddish brown soft clay	0.20	
Hard gray clay	1.10	
Soft whitish brown clay	0.30	
Hard dark gray clay	0.50	

		Feet.
Coal	0.10	
Soft dark gray clay	0.30	
Coal	0.60	
Soft dark gray clay	0.20	
Bad *coal*	0.45	
Soft light gray clay	0.10	
Coal	0 15	
Soft light gray clay	0.05	
Bad *coal*, (Q 532 a)	0.80—	5.75
Hard reddish brown clay, exposed perhaps		3.00
Unknown		15.00
Reddish gray coarse grit, (Y 629 jb), exposed perhaps		3.00
Unknown		30.00
Reddish gray sandy clay, exposed perhaps		1.00
Soft gray clay		0.10
Coal	0.20	
Soft whitish gray clay	0.10	
Coal	0.70	
Reddish brown fine sand rock	0.30	
Coal	0.10	
Reddish bad *coal*, (Y 646 fa)	0.45—	1.85
Whitish hard gray clay, exposed perhaps		1.00
Gray shale, (B 952 f), exposed perhaps		14.00
Unknown		9.00
Soft gray clay		0.10
Coal, (Q 531 e)		0.30
Hard gray clay, exposed perhaps		3.00
Unknown		30.00
Hard gray clay, exposed perhaps, (U 383 a)		3.00
Unknown		110.00
Bluish gray hard sand rock, containing fossils, exposed perhaps		5.00
Coal and coal slate, (Y 721 b)		8.00

		Feet.
Bluish gray hard sand rock, containing fossils, exposed perhaps		7.00
Unknown		42.00
Brownish gray shale, exposed about		20.00
Coal, an irregular streak		—
Fine grained gray sand rock, from 0 to 5 feet, say		3.00
Reddish gray soft sand rock, about		0.30
Greenish gray shale, about		7.00
Fine grained gray sand rock, about		1.00
Sand rock with fossil shells, about		2.00
Hard brown shale		6.00
Sand rock with fossil shells, about		13.00
Reddish brown shale, about		12.00
Coal with layers of grayish brown clay		6.00
Clay		10.00
Coal, (B 884 e), about	3.00	
Brownish gray clay	1.00	
Good *coal*	0.70—	4.70
Hard brownish gray shale, about		10.00
Bluish gray shale, about		2.00
Bluish gray soft sand rock, about		5.00
Unknown		48.00
Bluish gray soft clayey sand rock, about		1.70
Bluish gray sand rock, (B 884 f), about		1.70
Unknown		14.00
Bluish gray sand rock, exposed perhaps		2.00
Coal, (B 884 g), about		0.40
Unknown		22.00
Soft clay, exposed perhaps		1.50
Bad *coal* (U 533 j)		2.50
Hard clay, exposed perhaps		1.50
Unknown		5.00
Soft clay, exposed perhaps		2.00
Good *coal,* (U 533 k)		1.20

		Feet.
Greenish gray shale, exposed perhaps		2.00
Unknown		10.00
Greenish gray shale, exposed perhaps		2.00
Coal, (U 533 l)		0.10
Greenish shale, exposed perhaps		2.00
Unknown		33.00
Coal slate, about		0.50
Coal, (B 884 i), about		0.30
Coal slate, about		0.50
Unknown		17.50
Bad *coal,* (U 533 h)	2.50	
Gray clay	0.50	
Coal	0.20—	3.20
Brown clay		0.30
Greenish gray shales		1.50
Unknown		62.00
Bluish gray clay shales with fossils, exposed perhaps		3.00
Coal, pretty good	3.16	
Coal slate	1.16	
COAL, pretty good, (B 884 k), BIBAI UPPER BED	3.16—	7.48
Dark gray clayey sand rock, exposed perhaps		2.00
Unknown		15.00
Greenish gray shales, exposed perhaps		1.00
Bad *coal,* (U 532 f)		0.70
Greenish gray shales, exposed perhaps		1.00
Unknown		32.00
Greenish gray shales, exposed perhaps		1.50
Good *coal* (U 532 d)		0.80
Greenish gray shales, exposed perhaps		1.50
Unknown		15.00
Soft clay, exposed perhaps		1.50
Good *coal*	0.50	
Coal slate	0.80	

		Feet.
Bad *coal*, (U 532 c)	1.10—	2.40
Coal slate, exposed perhaps		1.00
Soft clay, exposed perhaps		1.00
Good coal (U 532 b)		0.75
Clay shales, exposed perhaps		2.00
Unknown		20.00
Sand rock, exposed perhaps		2.00
Light brownish gray shales, about		5.00
Coal, bad and soft, (B 884 ma)		7.70
Light brownish gray soft clay		1.70
Greenish gray hard sand rock, containing much *coaly* matter		2.50
Light gray hard shales, gradually becoming sandy, exposed perhaps		3.00
Unknown		66.00
Greenish gray sand rock, exposed perhaps		7.00
Greenish gray sand rock with fossil shells, (B 885 o), about		4.00
Greenish gray sand rock, exposed perhaps		9.00
Unknown		20.00
Hard greenish gray sand rock		2.00
Soft greenish gray sand rock		5.00
Gray pebbles with dark gray and blackish quartzite pebbles, (B 931 j)		4.00
Greenish gray sandy shales		12.00
Fine greenish gray sand rock, perhaps		10.00
Unknown		30.00
Greenish gray shales, about		3.00
Limestone, (B 885 p)		1.00
Greenish gray sand rock, perhaps		10.00
Many thin layers of shales of different colors		2.00
Greenish gray shales, perhaps.		5.00
Unknown		40.00
Gray shales, exposed perhaps		6.00

		Feet.
Rotten bony *coal*	1.00	
Soft bluish clay	0.15	
Firm good *coal*, (U 564 k)	2.30—	3.45
Gray shales, exposed perhaps		5.00
Unknown		9.00
Grey pebble rock with dark gray and blackish quartzite pebbles		2.00
Greenish gray shale		6.00
Coal slate, (B 885 r)		0.40
Greenish gray sand rock, about		6.60
Unknown		5.00
Greenish gray sand rock, perhaps		10.00
Unknown		70.00
Soft clay, exposed perhaps		2.00
Bony *coal* (U 566 d)		1.10
Gray shale, exposed perhaps		4.00
Unknown		2.00
Firm good *coal*, (U 564 h)		1.10
Gray shale, exposed perhaps		10.00
Unknown		185.00
Sandy gray shales, exposed perhaps		5.00
Soft coal, (U 563 ea)		0.30
Sandy gray shales, exposed perhaps		5.00
Unknown		106.00
Greenish gray sand rock		5.00
Gray pebble rock with dark gray and blackish quartzite pebbles, (B 887 ea)		3.00
Greenish gray sand rock		4.00
Unknown		15.00
Greenish gray sand rock, (B 930 e)		20.00
Unknown		65.00
Greenish gray sand rock, (B 888 ha), perhaps		10.00
Unknown		14.00
Soft clay, exposed perhaps		2.00

		Feet.
Coal, good but soft, (U 572 cb)		0.80
Grayish brown clay shale, exposed perhaps		2.00
Unknown		85.00
Coal with many layers of reddish or brownish clay and shale, (Y 669 nb), about		1.70
Unknown		10.00
Lime rock, (B 888 j)		0.50
Greenish gray sand rock		1.00
Lime rock.		0.50
Unknown		38.00
Grayish white sand rock, (B 888 la)		1.50
Unknown		5.00
Greenish gray shale, (B 888 lb), perhaps		3.00
Unknown, perhaps		7.00
Greenish gray shale, (B 888 m), exposed perhaps	20.00	
Greenish gray shale, exposed perhaps	5.00—	25.00
Bad *coal* much mixed with earth, (B 888 n)		0.10
Greenish gray shale		1.00
Unknown		25.00
Lime rock		1.00
Greenish gray sand rock with fossil leaves		2.00
Coal slate		0.70
Hard greenish gray sandy shale		4.00
Hard greenish gray sand rock		2.00
Light gray coarse grit		7.00
Gray clay		0.20
Light gray coarse grit		3.00
Gray clay		0.10
Gray pebble rock, with dark gray and blackish quartzite pebbles		4.00
Greenish gray soft sand rock		0.50
Gray pebble rock, with dark gray and blackish quartzite pebbles		1.50

		Feet.
Greenish gray shale		3.00
Bad *coal* much mixed with earth, (E 444 ba)		1.00
Unknown		7.00
Greenish gray sand rock, (E 444 d), perhaps		5.00
Unknown		50.00
Limestone balls		1.00
Greenish gray shales		4.00
Limestone balls		1.00
Greenish gray shale		2.00
Limestone		1.00
Greenish gray shale		4.50
Bad *coal* much mixed with earth,(E 445 h)	0.20	
Greenish gray shale	2.00	
Bad *coal* much mixed with earth	0.20—	2.40
Greenish gray shale		5.00
Limestone balls		1.50
Limestone		0.50
Unknown		25.00
Bad *coal*, (E 445 j)		0.90
Greenish gray sandy shale, perhaps		15.00
Unknown		16.00
Hard greenish gray sand rock		1.00
Soft greenish gray sand rock		0.30
Gray pebble rock with dark gray and blackish quartzite pebbles (B 929 ta)		2.00
Greenish gray coarse sand rock		4.00
Unknown		10.00
Bad *coal* (B 926 f)		3.00
Greenish gray sand rock		3.00
Coal slate		1.00
Greenish gray sand rock		2.00
Limestone		1.50
Unknown		5,00

		Feet.
Hard coarse greenish gray sand rock, very hard at bottom, (B 926 r) and (B 889 oa), in all perhaps		20.00
Unknown		3.00
Greenish gray shale, (B 929 q), perhaps		15.00
Unknown		26.00
Soft fine gray clay		0.30
Brownish *coal*, (B 889 y)	0.60	
Coal slate	0.50	
Coal	0.40—	1.50
Unknown		100.00
Coal, (E 420 ba)		0.15
Coal slate		0.15
Greenish gray shale		1.00
Unknown		100.00
Greenish gray sand rock		0.50
Greenish gray shale		1.50
Bad *coal* much mixed with earth, (E 420 d)	0.10	
Limestone balls	0.60	
Bad *coal* much mixed with earth	0.10—	0.80
Greenish gray shale		1.00
Unknown		40.00
Greenish gray shale		0.50
Bad *coal* much mixed with earth (E 421 f)		0.10
Greenish gray shale		0.50
Unknown		4.00
Soft brown shale		1.00
Bad *coal* much mixed with earth	2.50	
Good *coal* (E 421 h) SANKEBIBAI BED	1.50—	4.00
Greenish gray sandy shale		2.00
Unknown		14.00
Bad *coal*	1.80	
Good *coal*, (E 421 i)	1.00—	2.80
Greenish gray sand rock		1.00

		Feet.
Unknown		27.00
Greenish gray shale, perhaps		15.00
Limestone, (B 926 p)		1.50
Greenish gray sand rock		3.00
Unknown		3.00
Greenish gray sand rock, perhaps		10.00
Coal slate, (B 926 q), about		15.00
Greenish gray sand rock, perhaps		20.00
Unknown		40.00
Green sand rock, exposed perhaps		2.00
Greenish gray shale		1.20
Fine grained sand rock, (B 927 z)		2.00
Greenish sand rock, exposed perhaps		2.00
Unknown		10.00
Coal slate exposed perhaps		2.00
Bony *coal*	2.50	
Good COAL, (U 607 pc), BIBAI LOWER BED	1.50—	4.00
Gray shale, exposed perhaps		1.00
Unknown		3.00
Soft clay exposed perhaps		1.00
Bony *coal*	1.20	
Good *coal*	1.00	
Bony *coal*	0.60	
Good *coal*, (U 607 pb)	1.20	
Bony *coal*	1.50—	5.50
Coal slate		5.00
Bad *coal*		1.50
Unknown		28.00
Light brown shaly sand rock		1.00
Bony *coal*, (U 607 pa)		1.80
Unknown		35.00
Sand rock with fossil shells, (U 607 o), exposed perhaps		12.00
Unknown		32.00

	Feet.
Coal slate, (E 423 r)	4.50
Greenish gray shale	2.00
Unknown	10.00
Coal slate, (E 423 sa)	2.00
Unknown	11.00
Greenish gray shale	1.00
Coal slate	4.00
Greenish gray shale	6.00
Bad *coal*, (E 423 v)	0.20
Greenish gray shale	1.00
Unknown	20.00
Greenish gray shale	2.00
Greenish gray sand rock, (E 423 wa)	2.00
Unknown	15.00
Greenish gray sand rock, (E 423 x)	7.00
Unknown	35.00
Greenish gray hard sand rock, (E 424 z), perhaps	5.00
Unknown	12.00
Gray sandy shales, weathered brown, exposed perhaps	4.00
Coal slate (U 867 ia)	2.50
Unknown	15.00
Gray sand rock, weathered brown, (U 867 i), say	6.50
Greenish gray hard sand rock, (E 424 b), perhaps.	5.00
Sand rock, (N 739 da)	8.00
Coal slate, (E 424 c), perhaps	1.20
Unknown	5.00
Greenish gray shale	1.50
Coal slate, (E 424 d)	0.80
Greenish gray shale	5.00
Unknown	30.00
Sand rock with fossil shells, (U 607 la), exposed perhaps	12.00
Unknown	45.00

	Feet.
Greenish gray coarse sand rock, (E 424 g), perhaps.	10.00
Unknown	17.00
Gray sand rock, weathered brown	7.00
Gray sand rock, with fossil shells and small silicious pebbles	1.00
Gray sand rock, weathered brown (U 867 l)	5.00
Unknown	70.00
Greenish gray sand rock, (E 425 k)	7.00
Unknown	50.00
Greenish gray shale, (E 425 l), perhaps	5.00
Unknown	12.00
Greenish gray sand rock (E 425 m), perhaps	5.00
Unknown	280.00
Very fine black weathered sand rock (Q 747 cd), say	6.00
Unknown	10.00
Clay shales (Q 747 ce) say	4.00
	6,437.98

It may be seen from the section that there are 79 coal beds known in all, and that they are especially thick and numerous near the upper end of the section ; likewise that limestone is apparently very rare throughout the whole section though thin beds of it occur near the middle, and a few elsewhere chiefly in balls; and that any rich enough in iron fairly to deserve to be called ore has not yet been found anywhere. The rocks of the upper end of the section are exposed at Poronai; of the next lower part at Nuppaomanai ; of nearly the lowest part on the upper Bibai ; and the lowest of all on the Sankebibai and Naie.

In the Makumbets Coal Field about ten leagues north west of Urakawa the section of 2,250 feet resembles the upper part of the Bibai section. The coal beds on the Sorachi river, half a dozen miles above (east of) its mouth on the Ishcari and some ten miles (4 ri) north of the Naie Survey, are some of them much thicker than those of Poronai, but yet seem to be the same beds, improved in thickness and of very good quality also. What rocks may occur above the top or below the bottom of the main section are wholly unknown ; but it is improbable that among them are any coal beds; and it is hardly likely that the coal bearing rocks have on the whole much greater thickness than the already great one of about 6,500 feet. Mr. Munroe has called attention to the fact that there are such continuous exposures of the coal bearing rocks along the shore for fifty miles (20 ri) near Urakawa and north-westward, that probably by a survey there a good section of perhaps 5,000 or 6,000 feet in thickness might be made. If it should indeed prove to be so thick, it would possibly correspond to a very large part of the section given above,

The rocks of the Horumui Group are at Kayanoma. Poronai, and on the Ichikishiri chiefly folded with axes running in a direction just about north-east and south-west (true bearing); but on the Sankebibai and Naie chiefly or wholly with north and south axes ; and on the Bibai, and still more in Nuppaomanai, north and south axes are combined with north-east and south-west ones. On the Sorachi the axes seem to run somewhat northerly of north-east and in the Akkeshi coal field still more nearly north and south.

At Poronai the combination of the two systems of folding is already beautifully perceptible in a slight curve of the main, north-east and south-west axis and in the accompanying north and south direction given to one side of the north-westerly basin, facts which the comparatively numerous coal exposures and the consequently more thorough study that could be given to them have made satisfactorily evident. In other parts of the same field an effort apparently to produce north and south folds has produced faults in that direction. On the Bibai, although the north-east and south-west direction is much the most prominent, yet the north and south one is very strongly marked giving subordinate waves or wrinkles upon the surface of larger, principal folds. In Nuppaomanai, the north and south folds are still more distinct and in one part of the survey become the principal ones, while towards the southern end of the survey they at least cause rather important modifications of the shape of essentially north-east and south-west folds. In the distant Kayanoma Coal Field two sets of complete folds have not been observed; but in addition to the main, north-east and south-west axes, there are faults, that may be considered as broken folds, or the result of efforts to produce folding; the direction of which however is apparently north twenty degrees west instead of north and south.

It is hard to tell whether the two sets of folds in the Ishcari valley coal group were produced at the same time, as for example by pressure from two different directions at once; or whether after one set of folds had been formed by pressure in one direction, the other set was produced by pressure in another direction. Rocks that have already been folded or corrugated would apparently offer greater resistance than wholly unfolded rocks to a new folding; and would therefore break in faults more frequently. It is therefore likely that the north and south folding, which seems in many places to have caused faults, is of a later date than the north-east and south-west folding. That would also account for the fact that although the coal bearing rocks or Horumui Group is often, and even chiefly, folded in the north-east and south-west direction, the later Toshibets Group of rocks has not yet been found to be so folded, but is even in the neighborhood of Poronai very sharply folded in the north and

south direction with almost vertical dips. In the same place therefore two sets of folds would seem to be generally of different dates ; and probably the axes of the same date would have the same general direction throughout a considerable space. But the parallelism of such simple folds within comparatively narrow limits is probably not always precise by any means ; and it seems reasonable to suppose that the limits within which a general parallelism exists for folds of the same age would be very far from world wide. The world is after all pretty wide, and pressure from one direction and resistance from another with the consequent folding, accompanied sometimes by earthquakes, may perhaps not be felt in the least degree at some rather distant point where pressure or resistance from quite different directions may be producing folds that are not at all parallel to the others.

It is even possible that the discrepancy in the course of the axes in the yet insufficiently studied Akkeshi Coal Field as compared with that of the Poronai axes, or in the bearings of the Kayanoma and Poronai faults, may be due to the effect of distant local differences of direction of the folding sidewise pressure (either as it was originally, or as it became where modified by special local resistance) rather than to any difference in the time when the two portions of each of those sets of axes and of faults were respectively produced.

g. Kamoikotan Group.—The rocks of the Kamoikotan Group would appear to form the core of the Island reaching in a shuttle shape from Cape Erimo northward to the middle Teshio valley, and crossed near its widest part and near the centre of the Island by the Ishcari river. There seems also to be a patch of it that fills up the greater part of the south-western branch of the great peninsula near Matsmai ; and perhaps one or two much smaller spots of it on the eastern side of Volcano Bay and near the head waters of the Toshibets. The group is intended to include many metamorphic rocks, that are commonly associated together, in locality dip or appearance, and are supposed to be of about the same age ; but no fossils have yet been found in any of them and their age is quite unknown. From their look alone they might seem to be of very great age, though that would perhaps be a deceptive method of judging. I have not heard either that corresponding rocks in the neighboring island of Nippon have disclosed any fossils that would indicate their age, or that they anywhere overlie rocks of known age. In Yesso they seem to be the oldest rocks of all and to have been probably the first nucleus of the Island about which the other formations one after another gathered.

On the Ishcari they seem to extend through the whole upper valley above the rocky gorge called Kamoikotan (Home of the Gods), which is the upper boundary of the middle waters of the river. They are chiefly blackish quartzites, though at Kamoikotan itself there are talcose and quartzose schists, a bed of blue marble seven feet or more thick and one of blackish serpentine probably over five feet thick. The blackish quartzite however is found here and there very widely through the valley and on the pass between it and the Otopchi, and pebbles of such rock are found in almost every stream of the upper Ishcari valley and in the tufa pebble rocks all along the north-east coast. Blackish quartzites are also found at many places in the large patch that ends on the south-west at Matsmai ; but at the north-eastern end of the patch on either side of Hakodate, and within four leagues of it, there are metamorphic limestones, not crystalline enough to be called marble, at Garonosawa on the west and at Kamiyunosawa and Ishizaki on the east, and their quantity seems to be very great. At Biroö, on the south-east coast, some ten leagues north of Cape Erimo occurs a greenish impure limestone that seems to belong also to the Kamoikotan Group. Some granites and mica schists, reported by Mr. Munroe as found in the southern point near Cape Erimo as well as in the south-western part of the Island just mentioned have likewise been classed with the same Group, though possibly not quite justly so. It may be, too, as already remarked, that a few of the blackish rocks on the upper Ishcari are in reality Old Volcanic rocks instead of blackish quartzites of the Kamoikotan Group. Some of them would seem indeed not to be quartzites as they were at first sight taken to be, but very dark feldspathic rocks. Particularly at the great Falls on the Upper Ishcari there are hot springs, which probably in Yesso always come from Old Volcanic rocks. Near Kuroiwa on the eastern shore of Volcano Bay is exposed a dark feldspathic rock with amygdaloidal masses of chalcedony, and that rock also has been reckoned as belonging to the Kamoikotan Group, though possibly it may turn out to be an Old Volcanic one. No section of any great thickness of the group has been made chiefly because of the absence of any large quantities of minerals of economic value, which has led to passing most of its exposures rather hastily by, excepting in some measure the limestone.

The structure likewise has not been anywhere very thoroughly studied out, but the axes seem almost everywhere to run nearly north and south, the direction of the main body of the Group; and the same direction seems to prevail not only on the Upper Ishicari, but near Cape Erimo, and in the large south-western patch of the Group, as may well be seen at an anticlinal axis in the Garonosawa valley. The resemblance in direction between the axes of that oldest, Kamoikotan Group, and of the comparatively very new Toshibets Group is complete and very striking and seems to give a good instance of the recurrence of a system of folding in a certain direction at different times. It seems probable that the north and south direction of the long narrow island of Sagalin (as well perhaps as that of the north end of Yesso) is due rather to the later system of folding than to the older; since the rocks so folded on Sagalin from the little we know of them would seem to be newer than the Kamoikotan Group, and those at the southern end seem to be Old Volcanic rocks like those of the northern end of Yesso, which themselves lie mainly in north and south folds.

The dips of the rocks of the Group are generally very steep, commonly more than 45° and often 60° or more.

Among the exceptional minerals that have been found in the Kamoikotan Group, may be mentioned the lead and zinc ores of the Ichinowatari mine, some eight leagues north-north-west of Hakodate. The ore however occurs in veins which seem also to break through Old Volcanic rocks; and as the other ore bearing veins of Yesso (with posssibly one or two exceptions at Yurap of the same character as that of Ichinowatari) seem to be confined to the Old Volcanic rocks and therefore probably to obtain their metals from those rocks, it seems likely that in this case also the metals are of volcanic rather than of Kamoikotan age. Mr. Munroe, however, as one result of his surveys of the principal gold fields of Yesso holds the opinion that the gold sand of the alluvium came originally from the old metamorphic rocks, which I have classed with the rocks of the Kamoikotan Group. He urges that near every gold field there are such metamorphic rocks, and in one or two cases (as Esashi, of the south-western coast) no other rocks older than the alluvium. It has, however, struck me as possible that the gold may have come from the Old Volcanic rocks; for they also occur near almost every field and in one case, that of some small gold washing reported to have been made north of Shibets at the eastern end of the island, no rocks but Old Volcanic ones seem to occur in all that part of the island ; and at two other gold washing places near Shirannka (half a dozen leagues west of Kusuri) besides alluvium there seems probably to be no other older rocks than the Toshibets Group except Old Volcanic ones. It is also not wholly impossible that some connection even at Esashi with the not very distant Old Volcanic rocks may be hereafter found to have existed.; and it is also possible that some of the granitic or other feldspathic rocks hitherto classed with the Kamoikotan Group may prove to be Old Volcanic. It is simpler to suppose that the gold (as some of the facts mentioned seem rather to indicate) occurred originally along with the other metals only in the Old Volcanic rocks to which all those other metals seem on the whole to be originally confined. No assays, however, so far as I know, have been made to test the amount of gold that the ores of the Old Volcanic rocks may contain, and it is probably very small at any rate, as the poorness of even the concentrated alluvium would seem to show. It is true moreover that some iron pyrites occurs in slates taken to be of the Kamoikotan Group, a few leagues south of Esan ; and it is possible that the gold may be associated with such pyrites, though no other metallic veins have yet been found wholly confined to the Kamoikotan Group ; while several are apparently confined to the Old Volcanic rocks. It should also be admitted that the small amount of gold of the Shibets and Shirannka places might possibly have come from some bed of the tufaceous pebble rocks, which often contain numerous fragments of the black quartzites of the Kamoikotan Group ; or in the case of the Shirannka gold, from beds of the Toshibets Group near by, for those beds might also contain fragments of the Kamoikotan Group (though much more commonly having those of Old Volcanic rocks). It is moreover barely possible that Kamoikotan rocks may be found to occur not very far inland from Shiranuka.

4. *Useful Minerals.*—Of the useful mineral substances of Yesso particular mention may be made of Coal, Iron, Gold, Sulphur, Limestone, Gypsum, Water (both the power giving water of rivers and the water of mineral springs), Oil, Lignite, and Peat ; and some other minerals which exist at least in traces, such as Lead, Zinc, Manganese, Copper, Silver, and Orpiment.

a. Coal.—The long section above given of the Horumui (or Brown Coal Bearing) Group shows that there are in the Ishcari valley at least ten coal beds that are more than three feet thick and at the same time of good quality, so that they may be considered as workable at once. The coal beds of Kayanoma and of the Makumbets coal survey correspond apparently to certain beds in that same section, and not improbably a like correspondence will be found between the coal beds of the Akkeshi coal field (at least one of them being workable) and those of the Ishcari valley.

Besides the ten fairly workable coal beds there are nine others also three feet or more in thickness (one of them 7.7 feet thick) which however seemed of poor quality to the assistants (at that time perhaps too inexperienced) who found them in making the Nuppaomanai and Bibai surveys. They may however prove to be workable, especially if it should only require care in mining to separate much of their slaty matter, or if it should be possible to crush and wash them cheaply and coke them either by themselves or mixed with the coal of other beds.

Moreover there are ten beds of coal between two and three feet thick that may be considered as of workable character within the long period of time it will take to exhaust even the better beds. Indeed for the measurement and calculation of the whole amount of workable coal in Great Britain by a government commission there four or five years ago, coal beds were reckoned as workable that had a thickness of only one foot. At the same time the limit of workable depth for any coal bed was decided to be probably four thousand feet; below that the heat, which increases on approaching the centre of the earth, would be too great to admit of the labor of mining. It is however difficult to decide with positiveness that in the centuries that must elapse before such a mining depth will be absolutely required to keep up the supply of fuel there may not be such improvements in mining and mining machinery that little labor (and that not severe) of men or beasts may be any longer necessary in mines, nor that the worked portions of extremely deep mines may not be so shut off and reduced in extent as to enable them to be ventilated and cooled by a rapid draft of air with a part of which the machinery would also be driven.

But of course, those very deep and less accessible portions of the coal beds are at present of much smaller importance than what is near to the surface of the ground and especially than what lies at a higher level than the channels of the adjacent water courses, and can therefore be mined without the expense of pumping out the water, nor of raising the coal in order to bring it to the surface of the ground. The depth of a few hundred feet below the lowest neighboring stream would however cause no enormous expense for pumping or hoisting; and might even be more favorable sometimes than the necessity of hauling the coal a very long distance along a level in the mine in order to reach the surface at some low valley.

The quality of the coal may be judged from the results of some assays and analyses made for our survey by Mr. Munroe in 1874, of which a special report was published.

The true relative position of the different beds had at that time been far less satisfactorily ascertained than it has been now ; so that a few words are necessary here to explain to which of the above mentioned beds the assayed specimens belonged ; and some of the principal results of the assays and analyses may be recalled by the two accompaning tables.

In descending order, at Kayanoma :

The Hurushiki Coal is probably the same as the Osawa No. 4, the Hamba No. 3 and the Onkosawa No. 5.

The Midzunuki Coal is the same as the Osawa No. 1 and probably the Onkosawa No. 4.

The Honshiki Coal is the same as the Kosawa No. 1, the Osawa No. 2, and probably the Hamba No. 4 and the Onkosawa No. 3.

The Osawa No. 6 Coal is the same as the Kosawa No. 2 and probably the Onkosawa No. 1 and the upper part of the Kirarayama Shimonose.

The Tateire No. 2 Coal is the same as the Kosawa No. 4 and probably the Takarasawa No. 2, the Osawa No. 8 and the Chatsunai Shimonosawa No. 2.

The Osawa No. 9 Coal is the same as the Takarasawa No. 3, and probably the Hamba No. 5.

The Ogurasawa No. 3 seems to be exposed nowhere else.

Likewise at Poronai :—

The (L 576 i) Coal is the No. VI Bed, and is the same as that of (L 1996 b).

The (L 602 a) Coal is the No. V Bed, and is the same as that of (L 602 cb) and (L 606 m).

The (L 602 ba) Coal is the No. IV Bed, and is the same as that of (L 602 ca), (L 603 e), (L 602 bb) and (L 606 ia), and probably (L 603 g).

ULTIMATE ANALYSES, PER CENTAGE RESULTS.

	Moisture.	Carbon.	Hydrogen.	Oxygen and Nitrogen.	Sulphur.	Mineral matter.	Combined water.	Free Hydrogen.
Hurushiki coal	1.342	69.049	5.256	7.172	2.386	14.795	6.718	4.510
Midzunuki coal (mine av.)......	3.714	57.689	4.620	10.144	3.765	20.068	10.062	3.502
Honshiki coal (mine av.)......	5.360	65.221	5.222	10.118	1.607	12.472	10.033	4.107
Honshiki coal (dump. av.)......	4.095	64.412	4.911	9.940	1.449	15.193	9.832	3.818
Tateire coal (mine av.).........	5.060	56.283	4.124	10.271	1.178	23.084	10.205	2.990
Horumui coal (L 602 a).........	5.194	72.982	5.300	13.841	0.353	2.330	14.221	3.720
Horumui coal (L 602 g).........	8.479	68.842	4.771	15.180	0.472	2.256	15.727	3.024
Sorachi coal No. 1...	2.928	77.040	5.685	11.014	0.542	2.791	11.041	4.458

The geological and topographical maps that we have made of our surveys of coal lands have made it possible to measure the extent of the different workable beds above certain levels throughout the limits of the surveys ; and so, by taking into account the thickness of each bed and the steepness of its dip, to calculate the cubic contents, or the weight, allowing a cubic yard to the ton. I have accordingly made such measurements and calculations for each workable bed in each survey, for the spaces above the lowest natural drainage level, within 500 feet below such drainage and between the 500 foot level and 4,000 feet below sea level.

In the Kayanoma survey there are six coal beds exposed that are workable through at least a portion of their extent although most of them seem to be so variable in thickness that they are not everywhere workable. That apparent variableness is so much greater than what has been found to exist in the Ishcari valley, that it may perhaps be accounted for by the fact that the observed coal exposures at Kayanoma may be in many cases (as they certainly are in some) close by faults, and may be merely thereby pinched into unusual thinness, which often happens in like circumstances, as may be seen inside the Kayanoma mines themselves. However, to prevent exaggeration only very small portions of each bed (except one) have been measured, those portions namely of which the outcrop exposures have a good thickness. Three of the beds have at those exposures an average thickness of six feet (one of them being the bed of exceptionally persistent thickness) and the averages for the three other beds are three feet and a half, seven feet and seven feet and a half; making all together a thickness of thirty-six feet The amount of coal capable of natural drainage was found to be probably 3,200,000 tons ; within 500 feet below water level, 6,050,000 tons ; making both together 9,250,000 tons. In addition, between the 500 foot level and 4,000 feet below sea level there was found to be probably 29,300,000 tons, making in all 38,550,000 tons. If the exposed coal beds really correspond to certain ones of the Ishcari valley (as seems to be the fact), then there may possibly be other workable beds at Kayanoma, chiefly at a lower depth, corresponding to the remainder of the workable ones near the Ishcari. But the Kayanoma field is too isolated and distant to count with any very strong probability upon such a complete agreement in the number and thickness of the beds. For while some of the coal beds were forming in the Ishcari region, it is possible that at Kayanoma there was no land at all or that other circumstances may have been unfavorable to the growth of the swamp vegetation that might by this time have been converted into coal. On the contrary it is rather surprising that in so remote a little field so much resemblance can be seen to the section of the Ishcari valley.

In the Poronai survey seven workable coal beds were found exposed with thicknesses (in decending order) of 4.70 feet, 5.10 feet, 5.79 feet, 3.33 feet, 3.56 feet, and 3.67 feet making in all 30.45 feet; taking in each case the average of the several observed exposures of the bed in Poronai. Besides that there are at less depth than 4,000 feet below sea level though reaching nowhere to within 500 feet of the surface, three beds that were found to be workable on the Bibai or Sankebibai with thicknesses of at least five feet, four feet and three feet; making the thickness of all ten together 42.45 feet. Of the seven beds there are found to be 6,520,000 tons above the lowest natural drainage level; and within 500 feet below that 9,345,000 tons; making in both portions 15,865,000 tons. Besides that in all ten beds between the 500 foot levels and 4,000 feet below the sea there are probably 84,450,000 tons; making all together 100,315,000 tons.

In like manner in the adjoining Ichikishiri survey, of the same beds there are above water level 7,560,000 tons; and within 500 feet below that 9,235,000 tons; making both together 16,795,000 tons. Also between the 500 foot levels and the 4,000 foot one there are probably 27,855,000 tons; making in all 44,650,000 tons.

In the Nuppaomanai survey, though only a league or so distant from Poronai the seven upper workable coal beds are not all exposed with thicknesses that correspond well to what they have in Poronai; two or three indeed have scarcely been observed at all, in spite of the fact that their part of the section necessarily comes to the surface there in many places. It is possible that some of the less promising exposures (hitherto only seen by the assistants) may on further examination prove to be imperfect ones; and that a more thorough search with our map now as a guide will lead to the discovery of the missing beds in something like their Poronai thickness. In the meantime, however, as the beds may perhaps have really grown so much thinner in Nuppaomanai as to be unworkable, the amount has been measured only of the three beds exposed there, reckoning at the same time in safe, round numbers the average of the thicknesses observed there; namely 6 feet, 4½ feet and 4½ feet. In that way it is found that there are above water level 4,195,000 tons; and within 500 feet below that, 7,645,000 tons; making both together 11,840,000 tons. There are also between the 500 foot levels and the 4,000 foot one probably 28,500,000 tons; making in all 40,340,000 tons.

In the Bibai survey (next north of Nuppaomanai) the seven beds are quite too high to be found anywhere either on the surface or below; and of the three lower workable coal beds only two were found to have a workable thickness. Perhaps it may turn out that the other may also be workable there; especially as it can now with the help of our map be looked for at many points on its outcrop that were before unknown. Nevertheless as it may not after all be workable on the Bibai its extent has not been measured there. The thicknesses of the other two have also for safety been reckoned quite below the average of their exposures at the round numbers of five and three feet. The two beds are found to have above natural drainage 3,060,000 tons ; and within 500 feet below it 6,000,000 tons ; making both together 9,060,000 tons. Moreover, there are between the 500 foot levels and the 4,000 foot one probably 10,000,000 tons ; making in all 19,060,000 tons, or in round numbers nineteen millions.

In the Sankebibai and Naie survey (just north of the Bibai survey) the seven upper workable beds are likewise far too high to occur at all ; and of the three lower beds only one was found to be of workable thickness, and the other two were not found at all. Although (as at Nuppaomanai) a further search may prove the two beds to be of satisfactory thickness, yet, for the present, measurement has been made only of the single bed that has shown itself to be of good thickness. At three places it averages 5.75 feet in thickness ; but as that includes some bony coal four feet was reckoned as a safe estimate of the average thickness. There were found then, to be 1,700,000 tons of the bed above water level ; and 1,800,000 tons within 500 feet deeper ; making both together 3,500,000 tons. Besides that, between the 500 foot levels and the 4,000 foot level (here in fact the very bottoms of the basins are at most only about 2,000 feet below sea level) there are probably 2,500,000 tons ; making in all 6,000,000 tons.

In the Makumbets survey, distant to be sure (northwest of Urakawa, near the coast), but apparently within the same great field as the surveys of the Ishcari Valley, and seeming to correspond in its section with the upper part of the Bibai Section, only one or two workable beds were found. One was found exposed and measured with a thickness of three feet and a half. Another had an old mine upon it, which could however no longer be entered, and the bed was reported to be four feet thick ; but an exposure near by that seemed an unsatisfactory one to Mr. Munroe (who had charge of the survey) would give only a thickness of one foot and a half of coal, so as to make it wholy unworkable. To be safe, then, from exaggeration, reckoning only the better exposed bed, there is found to be above water level (although very much of that portion of the bed lies outside the survey and was therefore not measured), 454,000 tons ; and within 500 feet below that level 1,581,000 tons ; making both together 2,085,000 tons. Besides that, below the 500 foot level, and reaching only to some 3,000 feet below sea level within the tract, there are probably 5,300,000 tons ; making in all 7,335,000 tons, or in round numbers 7,400,000 tons.

It appears, then, that of the measured workable coal of our surveys there are above water level 26,689,000 tons ; and within 500 feet below it 41,656,000 tons ; making above that very easy mining depth 68,345,000 tons. In addition there are between that depth and 4,000 feet below sea level probably 187,905,000 tons ; making in all 256,250,000 tons of well ascertained coal.

But, large as that amount is, it is very small compared with the whole amount of workable coal in Yesso. On measuring upon the geological map of the Island the extent of the coal fields, rejecting in the Akkeshi field all but about 100 square miles near Kusuri and in the main field a strip along the west coast, both of which rejected portions seem to contain no workable coal, there are still found to be over 5,000 square miles or about 850 square ri, that are probably productive, including a small space where the alluvium of the Ishcari valley seems to cover up the coal rocks. The Toshibets Group very likely also covers up the coal bearing rocks in many places ; but excepting the case of the alluvium, no such concealed coal measures have been counted. Some portions are of course more productive than others, just as some of our surveys have been shown to be richer in coal than others. In order to form at least a rough estimate of the whole amount of coal in Yesso it might perhaps be very safe to take our surveys in the main field as showing what the average of the whole productive area would be. The Kayanoma field is perhaps too exceptional in its character to be reckoned in such an estimate ; since for greater safety only a small portion of its coal beds were measured, and the survey extends perhaps very widely beyond the coal bearing rocks (5.9 square miles in all). Taking the other surveys, however, they may be seen to represent severally and in their different parts every degree of richness to the square mile ; and even many portions of the surveys are quite free of coal. Other portions have only one or two or three of the lowermost and thinnest workable beds. Others again have all ten workable beds; amounting however to scarcely a fifth of the whole extent of the surveys, a proportion very probably not greater than would apply to their extent through the whole of the great coal fields. Moreover the limits of the surveys have not been fixed with any reference whatever to the average amount of coal to the square mile that would result; so that the surveys may in fact be considered on the whole as samples taken at random of all the coal area. It is true that the number of such samples is rather too small to make the result perfectly trustworthy ; but yet it seems likely that the error will at least not be extremely great. Another source of uncertainty in the grand estimate is our ignorance of the true extent of the great coal fields ; for their limits have never been precisely ascertained. Still the estimate given of their extent is based upon a measurement of the surface assigned to them on the map as the most probable and assigned without the least prejudice or reference to making up any certain round sum of square miles. If then we divide the whole amount of measured workable coal in the surveys that were made in the main coal field, by the number of square miles of those surveys, we shall have an average number of tons to the square mile by which we may multiply the whole number of square miles (over 5,000) of productive coal measures.

The number of square miles in the different surveys are as follows: Bibai, 4.8 ; Nuppaomanai, 3.8 ; Poronai, 2.7; Sankebibai and Naie, 2.6 ; Makumbets, 1.9 ; Ichikishiri, 1.2 ; in all seventeen square miles.

Furthermore we find the whole amount of workable coal that is over three feet thick in the six surveys made in the main coal field to be: above water level 23,489,000 tons ; within 500 feet below that 35,606,000 tons ; in both together 59,095,000 tons. Besides that, between the 500 foot levels and 4,000 feet below the sea there are probably 158,605,000 tons ; making in all 217,700,000 tons.

If, then, we divide those amounts by seventeen we find as the average for one square mile of survey : above water level 1,380,000 tons ; within 500 feet below that, 2,095,000 tons; or both together, 3,475,000 tons. In addition, between the 500 foot levels and the 4,000 foot one, 9,330,000 tons ; making in all together 12,805,000 tons.

Then, if we multiply those averages by a trifle over 5,000 (that is, by the probable number of square miles of productive coal fields), we have for the whole amount of such coal in all Yesso : above water level 7,000,000,000 tons ; within 500 feet deeper 11,000,000,000 tons ; and both together, 18,000,000,000 tons. Moreover, between the 500 foot levels and 4,000 foot one, there would be 47,000,000,000 tons ; making, in all the round sum of 65,000,000,000 tons.

But so far we have reckoned only the ten beds that are three feet thick or more and of particularly good quality. There are, however, as already mentioned thinner beds of good quality and poorer ones of good thickness that may very well be considered as a part of the workable coal of the future ; for, even though they may not be so now, they are likely to become so before in the course of centuries the ten better beds shall become exhausted ; and at all events probably better deserve to be called workable here than one foot beds in England.

As the unmeasured beds are pretty evenly distributed throughout the whole column of coal bearing rocks, even more so than the measured ones, it will be safe enough to consider that their extent and number of tons will be as much greater than those of the measured beds as their combined thickness is greater than theirs. It may be seen from the numbers already given that the thickness of the ten beds added together would amount to 42.45 feet ; and that the other coal beds that are two feet thick or more amount in all to a thickness of sixty feet, or more than a third as much again as the ten measured beds. Increasing then the ton numbers just given by once and a third their own amount we have in round numbers for the whole workable coal that probably exists in Yesso : above water level 16,000,000,000 tons ; within 500 feet below that 25,000,000,000 tons ; or in both together, 41,000,000,000 tons. Besides that, between the 500 foot levels and 4,000 feet below sea level, 110,000,000,000 tons ; making in all 150,000,000,000 tons of workable coal in Yesso.

b. Iron.—Of magnetic iron sand the only workable deposits on the Island seem to be those of the beaches on the south-west shore of Volcano Bay and on the south-eastern end of the great peninsula. The Volcano Bay deposit stretches from Yurap past Okotsunai and Yamukushinai to Otoshibe, some ten miles (4 ri) in length; and is, on the average, say, twenty yards (ten ken) wide, and perhaps half a foot thick. It would contain therefore less than 60,000 cubic yards (7,500 cubic ken); and, if it should average eighty per cent of pure ore (being much mixed with other sand in spite of looking very rich in many parts) there would be about 120,000 tons of it, which would contain 87,000 tons of iron. There is in addition a very large amout of poorer sand either in underlying layers or in neighboring places, and perhaps with cheap labor more ore could be washed. For washing there is plenty of water in the small streams that cross the beach at every little distance. Wood for charcoal is abundant inland, and especially the Yurap valley would yield a large amount. Charcoal at present costs about a quarter of a cent a pound. The ore is rather infusible and hard to work alone, probably because it contains titanium; but according to recent English and American experience broken bricks would prove satisfactory flux for it. Iron sand, to be sure, is not well adapted for smelting in the blast furnace; yet it can be worked in a bloomary forge. Some iron works of that kind with two forge fires were set up near Okotsunai a dozen years ago, and were worked intermittently on a very small scale for half a dozen years, but were then abandoned and are now in ruins.

The iron sand on the south-east end of the great peninsula is much more fusible and probably comparatively free from titanium; but is much less in quantity. It is chiefly in three deposits: at Kobui (near Esan), at Shirikishinai (about a league to the south), and half way between. The middle place is the largest and has in its richest part perhaps 700 cubic yards of the mixed sand with perhaps 500 cubic yards or 1,000 tons of pure ore, containing 725 tons of iron; but there is enough rather poorer sand adjoining to make up perhaps 5,000 tons of ore in all, containing 3,650 tons of iron. The deposit at Kobui has perhaps 250 cubic yards of sand holding 200 cubic yards or say 400 tons of pure ore, which would contain 290 tons of iron. The Shirikishinai sand looks rather poor and seems to be only about 100 cubic yards in amount holding perhaps 140 tons of iron. It was worked about twenty years ago for three years for a furnace near by, built of clay in the Nambu form, seven feet long by four wide and five high. The iron is said to have been soft and pretty good though not the best; and the working was abandoned from lack of more ore.

No vein of solid ore has been found anywhere; but in a gully on the eastern side of Komangadake, at 1,150 feet above the sea and a league from it, a layer of magnetic iron sand a foot thick was found regularly bedded with the other volcanic rocks and about seven feet and a half from the surface of the hill. The covering is loose pumice. No exploration of the extent of the bed has been made.

The whole amount, then, of pure ore in the principal workable deposits of magnetic iron sand is perhaps 125,500 tons containing 91,000 tons of iron. Only 5,500 tons of the ore (containing 4,000 tons of iron) are of the easily workable kind.

There are several deposits of hard, coarsely honeycombed bog ore (limonite), which have perhaps been formed from what were originally alluvial deposits of magnetic iron sand. They are at Oyahuru (on the north bank of the Ishcari a league above its mouth), at Utsunai (on the opposite shore, a league up stream), at Bannaguro (another league up stream, on the south bank) and at two places near Hiragishimura, three or four miles south of Sapporo. The largest quantity seems to be at Oyahuru, but would hardly amount to 20,000 tons of ore. At one place near Hiragishimura there would seem to be perhaps 400 tons of the ore. The other places are all yet more insignificant by far; so that the whole amount of bog ore known in Yesso would probably not be more than 20,500 tons, containing at most probably not 10,000 tons of iron.

No good carbonate of iron has yet been found; but some of the limestone balls in the Coal Bearing Group seem rather heavy and possibly some may yet be found (let us hope) rich enough in iron to be worked as ore. One layer, a third of a foot in thickness, just under one of the coal beds on the Sorachi can perhaps be worked along with the coal.

The whole amount of iron then in the workable deposits of ore yet discovered, both magnetic sand and bog ore, would appear to be hardly more than a hundred thousand tons.

c. *Gold.*—Although traces of gold (as of iron sand ; but in a far less degree) are very widespread indeed the only two gold fields that have any pretension whatever to workableness are the Toshibets and the Musa ; and only small portions of them. The upper part of the Toshibets field has, according to Mr. Munroe's survey within a space of about a square mile with an average depth of about ten feet something over three million cubic yards of gravel that contains, at an average of 5⅔ cents' worth of gold to the yard, about $180,000 in gold that may be barely workable. In like manner about a third of an acre near Yunoshiri in the Musa field has about $400 of gold in gravel that yields perhaps 6⅔ cents to the cubic yard, but is unfavourably situated in regard to water for washing.

There are very extensive traces of ancient washings in both fields (covering on the Toshibets one half the field); and according to tradition they date back six or seven hundred years in the Musa field. The latest washings were in the Toshibets field and were abandoned about fourteen years ago. It is probable that the washing was done on the whole for a much smaller return in gold than would in these days be considered satisfactory, although the whole neighboring country was no doubt tried and the richest places worked by preference. Certainly in the spaces yet left unworked it would now be the height of imprudence to undertake any large washings by even the most economical methods. As some doubt has been publicly cast upon the conclusiveness of Mr. Munroe's tests, I would say that he was well aware of the tendency of the gold to be concentrated near the bed rock, and according to his statements to me kept the fact in view during his trials ; and I have no belief whatever that the richness of the gold fields has been underrated or that any thing will be found to justify the wild hopes of those who would have gladly plunged into large and costly mining operations without even a careful preliminary survey.

d. Sulphur.—Most of the sulphur in Yesso is deposited from volcanic fumes ; but near Kobui there is some gray sulphur that appears to be a deposit from sulphur springs.

The Itashibeoni sulphur near the eastern end of the island seems to be much greater in amount than that of any other place. The fumes rise in great volume from a hole some twenty feet long by fifteen wide at the bottom of a larger hole perhaps a hundred feet in diameter and thirty feet deep. The smaller hole is full to within five feet of its brim with a dark brownish-gray, muddy-looking liquid that seems to be melted sulphur and is boiling violently and spouting upwards for several feet in great commotion and sending out heavy sulphur fumes, apparently without any steam. A comparatively small portion of the fumes condenses as sulphur powder on the mountain side around, within 75 to 150 yards wherever the wind has blown them. About eight acres (or 9,600 tsubo) are wholly or partly covered by the sulphur to an average depth of half a foot or perhaps less of pure sulphur ; amounting, therefore, at one half that thickness, to perhaps 3,200 cubic yards, or say 3,200 tons (20,000 koku) worth at Hakodate some $60,000. If the brown liquid in the hole be indeed sulphur, and if by any method it can be dipped or pumped out, it is possible that the amount might be many thousands or even tens of thousands of tons. The place is about 2,000 feet above the sea, and two miles (30 cho) distant from it by the present difficult footpath ; but about half that distance from the shore at another point where however the cliffs are very high. There is no drinkable water known within a mile and a half of the sulphur. There are therefore some difficulties in the way of working the sulphur, and it was abandoned in 1867 after a trial of two summers.

At the other volcanic places the sulphur is deposited in the same way by condensation from fumes upon the cool ground, and is commonly much mixed with earthy impurites, partially decomposed rock and the like. At one place, Esan, where the sulphur was worked for some 15 years, it was estimated that throughout the extent of the deposit the average thickness of what was thought worth gathering was perhaps one-tenth of a foot ; and it yielded, it was said, four-tenths of its weight in sulphur. Taking that as a guide a rough estimate was made of the amount of sulphur to be won at the different places, as follows : Nuburibets, at two places a quater of a mile apart, namely, near the hot springs some 100 tons (or 600 koku), and near the Oi Lake, 35 tons (over 200 koku); at Iwaonobori, 75 tons (450 koku); at Tarumai (in 1873), 35 tons (over 200 koku); at Esan (in 1873), 30 tons (nearly 200 koku). The Esan place was reported last year to be practically exhausted, and the working was perhaps already abandoned. The eruption of Tarumai in 1874 may have lessened the present amount of sulphur there. Near the mountain Meakan in the eastern part of the Island sulphur was worked many (30?) years ago, but has long been abandoned; and as it was not visited during our survey no estimate was made of its amount. Probably it is not more than the average of the other places. There are also traces of volcanic sulphur on Usudake and on Komangadake.

Most of the volcanic sulphur, though it can be reached by horses, is rather inaccessible owing to the height at which it is found on the mountains and its distance from big roads, or the sea shore. The Nuburibets sulphur is, however, only 900 feet above the sea and four miles (1½ ri) from it and from the New Road; but the Iwaonobori sulphur is about 3,600 feet above the sea, and 14 miles (5½ ri) from it at Iwanai; the Tarumai sulphur, about 3,000 feet above the sea, and nine miles (3¾ ri) from it; the Esan sulphur, about 1,400 feet above the sea and a mile and a half (or half a ri) from it.

The sulphur was worked at Esan ever since nearly fifteen years ago. To separate the earthy impurities it was melted three times in three large iron pots two feet in diameter and three feet deep; and afterwards strained through thick canvas. The cost (delivered at Hakodate) as given me by the workmen amounted to $538 for 100 koku (about 16 tons), the product of three months, worth at Hakodate about $300. The Nuburibets sulphur was formerly worked (apparently with three melting pots), but was abandoned about nineteen years ago. The Tarumai sulphur was worked for three years (with five or more pots); but was abandoned about sixteen years ago. The Iwaonobori sulphur was worked for many years, but was abandoned about eight years ago.

Four or five miles (nearly two ri) from Kobui, at some old sulphur works, on the Musa River (not the gold field Musa), and at a place about a mile further to the northwest, there are bedded but very irregular layers of gray sulphur, apparently deposits from springs of sulphur water. At the old works (of 15 years or more ago) is a mine, a drift, that is said to be 240 yards (2 cho) long and to have followed a vein one foot thick that contained yellow sulphur in nests and single crystals but gradually grew poorer to the end. The gray sulphur was not mined there (on account of objections to the color, it is said) ; but is seen in one or two beds of two and four feet thick. At the other place, gray sulphur is exposed in the bank of a ravine for a hundred feet in length and a dozen feet in height, but partly impure ; perhaps one third of it is pure sulphur. Such deposits are not likely to be very widespread nor very uniform in thickness ; but perhaps there may be 200 tons of sulphur at the ravine and 25 tons at the old mines, possibly much more.

There are also traces of yellow sulphur at Nigorikawa, which however seem to have come from sulphur water, as there are no fumes there.

The whole amount of workable sulphur, then, in Yesso is perhaps 3,700 tons (or 23,000 koku) ; of which nearly six sevenths would be at Itashibeoni, and 200 tons would be the gray sulphur of Kobui.

e. Limestone and other Building Materials.—The most of the limestone of Yesso belongs to the Kamoikotan Group, and is highly metamorphic, sometimes a marble. The largest amount is on the Garonosawa, a small stream a dozen miles from Hakodate across the harbor, and four miles from the sea shore. The dark blue and light gray limestone is exposed in cliffs on either side of the brook to a height of perhaps 600 feet for a distance of about four miles ; so that within a yard of the surface there would be some twenty millions of tons, and probably it extends many yards, perhaps hundreds of yards, deep below the surface. Something like 30,000 tons must be lying in loose blocks in the bed of the brook. Either a waggon road or a railroad could easily be built with down grade all the way to the sea shore. Wood at the limestone was said (in 1873) to cost two dollars a Japanese cord (125 feet).

At Ishizaki ten miles (4 ri) east of Hakodate there are cliffs 250 yards long of gray and white, pure looking lime rock, on the side of a bluff 85 feet high. There are perhaps 5,000 tons "in sight," but doubtless a far larger amount exists behind. Within 100 yards from the face of the bluff there would be two millions and a quarter of tons above sea level.

At Kamiyunosawa about five miles (2 ri) north-east of Hakodate lime rock of good quality is exposed here and there on both sides of a very small valley for a quarter of a mile, perhaps to the amount of 2,000 tons. But no doubt here also the amount behind what is exposed is far greater. The Kaitakushi in 1873 had for a year had a kiln there burning lime, but the expense for wood alone was two and a half times the worth of the lime in Hakodate, according to the account given me. Wood was said however to cost only $1.45 a Japanese cord. The road to Hakodate is over nearly level ground free from rocks and trees; and could easily be made into a waggon road.

At Kamoikotan the upper limit of the middle Ishcari river, there is exposed a blue marble with white streaks that must form a bed at least seven feet thick, perhaps much more. Though not the handsomest kind of marble it may yet be used for ornamental purposes, as well as for making lime.

In the Toshibets Group, near Washinoki a gray, impure looking lime rock is exposed on the sea shore, about a dozen feet in thickness. If it be supposed to extend only a quarter of a mile inland (and it probably reaches much further) there would be over 43,000 tons of it above sea level.

In the Musa gold field Mr. Munroe found among the Chingkombe Shales a bed of lime rock eight feet thick, grayish white and rather siliceous, besides some smaller ones; and they perhaps correspond to the Washinoki limestone.

There are also in the Toshibets group especially in the Musa gold field beds that have limestone balls. Also in the Horumui Group at Poronai and on the Bibai and the Sorachi there are limestone balls, and on the Bibai even thin beds of limestone.

It is to be seen, then, that, although limestone is on the whole rather sparingly distributed through Yesso, it is yet far from being altogether wanting, and that near Hakodate it is even very abundant, and no doubt practically inexhaustible in amount. It is especially fortunate that it should be so conveniently situated for shipment southward for it may even help to supply the needs of Nippon, where, as I understand, it is so very rare that lime is commonly imported from China. An abundance of lime would have no doubt a very important influence on the architecture of Japan, and perhaps on its agriculture too.

The only deposit of gypsum known in Yesso is that of Yûnai, among the old volcanic rocks of Raiden mountain, three leagues and a half southerly from Iwanai. The gypsum forms a bed sixteen feet thick and is mostly bluish gray, soft and shaly and seems to be on the average very impure with clay ; but there are thin white crystalline often fibrous seams of pure gypsum, up to 0.2 feet or thereabouts in thickness, and innumerable minute crystals of white iron pyrites. The deposit is exposed through a length of about fifty feet in the side of a narrow ravine, and is overlain by some forty feet of loam containing blocks of greenish gray trachytic (or rhyolitic) porphyry with what seem to be sanidin crystals. Supposing the bed to extend with the same average thickness every way in the hillside to a distance of 100 feet from where it is seen there would be about 40,000 tons of impure gypsum ; supposing it to reach in like manner 1,000 feet there would be 1,600,000 tons ; perhaps it may be safe enough to count on a million tons.

Even if the gypsum be too impure to become white when calcined so as to be used as ornamental plaster, it might still be valuable to put on the farming lands of Yesso and Nippon, which are apparently very deficient in lime ; but the difficulty of shipment is a great obstacle in the way. The deposit is accessible only by a very narrow steep valley in which there is at present only a very imperfect foot path, which descending about 2,000 feet leads to the village of Abushita on the sea shore about a league distant. At Abushita there is no good harbor ; but vessels might lie off it with some safety during the summer. If a small tram road could be laid in the valley, and if a steamer could be sent from Iwanai to carry away the gypsum or to tow away vessels loaded with it, perhaps the deposit might be worked. But even then, the looseness of the earth and stones that lie above the bed through a thickness of forty feet at least would make it very difficult to gather any large quantity of the gypsum. It must therefore be considered for the present at least as quite unworkable on any large scale.

Of building stone (besides the limestone) there is a great abundance in almost all parts of the Island; for the old volcanic rocks are almost always of very durable quality as shown by the comparative sharpness of their outlines where they have been naturally exposed to the weather for ages. They are however in most cases very hard and will therefore be rather difficult to work. Many portions of the sand rocks of the Horumui or Coal Bearing Group and some of the Toshibets Group will be found hard enough to be used for building stone, and though probably durable will be much easier to work than the Old Volcanic rocks. The blackish quartzite rocks of the Kamoikotan group will be an extremely hard and durable building material, but very difficult to work. Not only will the blue marble of Kamoikotan be serviceable as an ornamental building stone; but the serpentine found there, belonging probably to a bed over five feet thick, will be very good indeed for the same purpose; and some of the Old Volcanic porphyries and granitic rocks will be very handsome when polished.

Of brick clay the only place worked is at Mohejigawa across the harbor from Hakodate; but no doubt an abundance of good material will be found in almost all parts of the Island, since the feldspar that forms the greater part of the volcanic rocks turns to clay in decomposing. The Mohejikawa bricks are very highly spoken of as compared with other Japanese bricks; but even there the burning seems to be insufficient and the product too soft and absorbent of moisture. The government tax on the manufacture (as stated in 1873) is enormous; and if removed or very much lightened, the business might become a very large one, and in the end yield the government far more revenue (directly or indirectly) than it does now.

Of fire clay there is a pretty large supply, as may be seen by the section of the Coal Bearing Group; and especially the bed a foot and a half thick under the Poronai No. 6 Coal bed seems particularly pure and likely to be serviceable.

f. Water.—The water of the rivers of Yesso will some day be highly valued as a source of power; and the water of many mineral springs is already highly prized for bathing and is in reality of great interest; not to speak particularly of the excellent springs, and clear streams of drinking water that abound there as in all mountainous countries.

Extremely few measurements of the power of any of the streams have been made; but two rough ones were made on the Ishcari river at Kamoikotan and at the Great Falls above the plain of the Upper River. At the Kamoikotan rapids the height of fall (if faith can be put in the hand levelling reported to me, and it did not seem improbable) is 54½ feet; and the discharge by my own rough measurement is about 3,250 cubic feet a second. There would be, then, (allowing 20 per cent. for loss of power by machinery) a little over 16,000 horse power. The valley is so narrow there that dams would not be long; at the lower end of the rapids, perhaps hardly 200 yards long.

At the Great Falls of the Ishcari the hand levelling on the same authority made the fall to be 47½ feet, and my rough measurement made the discharge of water to be about 1,000 cubic feet a second; giving (with the same allowance of 20 per cent. for imperfection of machinery) 4,300 horse power. The situation is such that a dam would hardly be needed at all.

Those two falls or rapids would give, then, over 20,000 effective horse power; and, although they are probably much the best cases in Yesso, still, there are so many thousands of places where by dams a good head of water with a good discharge might be obtained, that the amount of power mentioned is no doubt an extremely small part of the whole.

There are about thirty places where mineral springs occur in Yesso chiefly in the southern peninsula; and all but two or three of them have been visited during the survey.

Fourteen of the places have sulphur springs of various temperatures from coldness to boiling. They are: Oi Lake, near Nuburibets, one spring, a lake a quarter of a mile wide, 99°, or boiling at 900 feet above the sea; Nuburibets, ten springs, six at 99° (boiling), the others 83°, 81°, 78½°, 48°, besides cooler ones; Jôzankei, 17 miles above Sapporo, six large springs, 89°, 89°, 87°, 83°, 83°, 80½°; on the sea shore, 29 miles north of Shibets at the east end of the Island, "some small very hot sulphur springs;" Obune, near Kumadomari, south-east of Volcano Bay, four small springs, 78½°, 74°, 73°, 68°; Isoya, near Kumadomari and Shikabe, five springs, not large, 72°, 69°, 67°, 67°, 48°; Nigorikawa, near Ishikura and Washinoki, four small springs, 57°, 55°, 51°, 49°, besides many small cold sulphur springs within a mile towards the sea; Esan, three small springs 53°±, 50°±, 45° ?; Kakumi, north-west of Esan, three small springs, 50°±, 47°, 50 ?; Yūnai, in Raiden Mountain, near Iwanai, three springs, 49½°, 47°, 46°; Kusuri Lower, near Otoshibe, south-west side of Volcano Bay, three springs, one 45½°, two cold; Yudomari, at Yudomari (Sakkadzuki) copper vein, north-west of Kayanoma, four springs, 33°, 32⅕°, 29°, 27½°, sulphur? and copperas with gas; Kusuri upper, near Otoshibe, one small spring, 35°; Notap, near Otoshibe, one small spring, cold.

Nine places have iron springs, from 21° to 91°; namely: Shikabe, five small springs, 91° (the largest), 70½°, 70°, 44°, 42°; Shibets, on Shibets river, at the east end of the Island, five springs at least, with a discharge altogether of perhaps a dozen gallons (1½ cubic feet) a second, 86½°, 82°, 82°, 70½°, with a slight red iron rust deposit and an abundant white one, probably of silica; Paushibets, half a mile south-west of the last mentioned, three springs besides many small threads of water, with a discharge alltogether of perhaps one cubic foot, or eight gallons, a second, 81½°, 75°, with the same minerals as at the Shibets springs ; **Ishcari Falls** springs, below the falls, two very small springs, 47°, 45° besides a still smaller cold (sulphur ?) spring; Yumoto, south-east of Kudoö, three springs, 43°±, 43°±, 43°± ; Yunosawa, near Kudoö, two springs, 43°±, 32°± ; Yurap, near the mines, two springs, 39° (rather large), 35° (small) ; Yunokawa, six miles north-east of Hakodate, one spring, 35° ; Boro, near Otoshibe, two springs, 33°, 27°.

One place has a strongly copperas (?) spring, without gas, cold ; namely, Yunosaki, close by Washinoki.

Three places have nearly pure springs, 30° to 80° ; namely : the Akiyama springs a quarter of a mile above the Ishcari Falls, in two groups about 100 yards apart of two or three springs each, estimated at 80° ; Tomi, two leagues above Shikabe, one small spring, 50°± ; Kamiyunosawa, two leagues north-east of Hakodate, one pretty large spring, 30°.

All the springs probably come originally from Old Volcanic rocks although in many cases (as at Oi Lake, Nuburibets, Obune, Isoya, Nigorikawa, Esan, Kakumi (part), Kusuri Lower and Upper, Shikabe, Yurap, Yunokawa, Boro, Yunosaki, Tomi, Kamiyunosawa, Ishcari Falls) they issue immediately from alluvium, and in one or two cases (as the Yunosawa and the Akiyama springs) it was thought at the time of visiting them that the nearest rocks were metamorphic ones (of the Kamoikotan Group). In every other case they clearly came originally from Old Volcanic rocks ; and probably there are no exceptions.

g. Oil—There are three places, Washinoki, Yamukushinai and Idzumisawa, where rock oil has been found in Yesso besides extremely small traces near Atsuta.

The Washinoki oil had in 1873 been found at five points on the Washinoki brook about half a mile above its mouth ; and in 1874, a mercantile company dug six or seven pits near by to depths of about 50 feet, 30 feet, 25 feet, 20 feet and less. At the five old places the whole yield was in October, 1873, about two gallons (5 sho) a day. The 50 foot well appears to have yielded in 1874 about 16 gallons (4 to) a day ; and the 30 foot well to have had traces of oil ; the rest, none at all. The whole amount gathered in 1874 was probably about 200 gallons (50 to) ; and the works were then abandoned as too unprofitable, quite as the survey had led us to expect beforehand, although the map was not then ready to serve as a guide in digging.

At Yamukushinai the amount of oil seems to be still less. It is exposed in traces at a dozen different points mostly within a hundred yards of each other and of the sea shore. The daily yield of them all is probably less than half a gallon ($1\frac{1}{4}$ sho), and seven-eights of that was measured at one well in 1873. There is also something like a ton and a half of asphalt or dried oil.

The Idzumisawa oil is still more insignificant in amount. It is found at three points within ten yards ; but almost wholly at one ; and the whole yield was in October, 1873, less than five pints a day ($1\frac{1}{2}$ sho).

The oil at all the places is of much the same character, black and very thick, like tar ; and (at 60° F.) marks by Beaumé's scale 15° at Washinoki, and 11° at Yamukushinai and Idzumisawa.

Washinoki is decidedly the most promising place of the three for trying to work the oil, but even there the encouragement is extremely small.

h. Lignite.—The principal beds of fibrous lignite are the one of Kemushitomari, between Isoya and Kumadomari, where a mine was once begun, and the one of Tomigawa, across the harbor from Hakodate. At Kemushitomari the bed is only about a foot and a half thick; at any rate quite too thin to be workable with profit, especially as it is not a very pure fuel. The Tomigawa lignite is still thinner, perhaps a foot, and is therefore wholly unworkable. There is also a little unworkable lignite on the Tokachi a short distance from its mouth. Still smaller and very insignificant traces of lignite have been found in the rock at Torizaki, near Washinoki; and bits of it (perhaps loose pieces that have been washed into the alluvium) have been brought from the lower Shiribets, from the Hurubira and from near Mororan. But the deposits hitherto well observed are all so poor as to give no hope of finding any that will be workable.

i. Peat.—The thickest bed of peat yet found is the one close by the iron sand at the mouth of the Otsuki River, near Kobui, and it is eight feet or more in thickness. On the Ikushibets, the Horumui and the lower Toyohira beds of peat three feet thick or more are seen in the alluvial banks or bed of the streams. Although the thickness is so great, the quality of the fuel seems to be too impure to make it worth working, at least for the present.

j. Other Minerals.—Thin, unworkable veins of ores of zinc (blende), lead (galena), copper (pyrites), and manganese (carbonate) are found at the Yurap mines, Ichinowatari mines (near Ono, north-west of Hakodate), Akagami (near Matsmai), near Kudoö, at Yudomari (near Sakkadzuki), at Kimpozan (near Kayanoma), on the Horobets near Mororan, on the Toyohira near Jôzankei, all in the south-western end of the Island. At each place the blende commonly predominates over the galena; the copper is found only at Yudomari and at Kudoö; and the manganese chiefly or solely at Yurap mines. The Yurap and Akagami lead and probably that of other places contains a trace of silver. Manganese is also found in the form of psilomelane in a few large blocks in the Toshibets Gold Field. At the Jôzankei place there are also small traces (a few handfuls) of orpiment. The ores were worked especially at Yurap ; also at Ichinowatari and Akagami ; but the mines have long been abandoned (a dozen years or more) as unprofitable ; and there is nothing to encourage reopening them ; and all the other places are, if possible, still more unpromising.

5. *Working of Minerals.*—The working of the useful minerals may be looked at from two points of view ; that of natural or physical opportunities and that of political difficulties.

a. Natural Facilities.—With the exception of the small mines and two miles of poorly planned tram road at Kayanoma and a few wretched bridle paths, as at Esan, Iwaonobori, Nuburibets and Tarumai there may be said to be up to this time no artificial facilities whatever for the mining and shipment of minerals in Yesso. Indeed, with the exception of the coal and of the limestone near Hakodate there are no minerals in sufficient quantity there to justify any costly improvements for their working. There is however ample room for labor in opening mines and building roads or artificially improving river navigation and harbors for the working of those two minerals ; especially the coal (for the limestone is so easily accessible as to need nothing but short and simple tramroads, to be perhaps afterwards converted into steam railroads).

The most promising field for such labor in the near future, where a comparatively small outlay would soonest bring a handsome return and one likely to last a couple of generations at least is near the Kayanoma coal mines ; but a much wider and probably for many hundreds of years inexhaustible field is near the still better coal of the Ishcari valley, yet it is one that needs greater outlay and longer delay to begin with, and promises smaller proportional profits. If but a single large colliery or only two or three large ones were intended, it is likely that it would be best to give attention only to the Kayanoma coal ; but if the probable demands of the market within a few years would justify the starting of a greater number of mines, a good plan would be to begin first with the Kayanoma field, which in a year or two could yield a good amount of marketable coal, and to begin in the Ishcari valley at the same time, or as soon as the increased demands of the market seemed to justify it (when for example in a few years the present Takashima mines near Nagasaki shall have been exhausted) to open up mines and build railroads, which, if pressed, might also within two or three years give a good product.

In the Kayanoma Coal Field there are the great advantages of nearness to the sea and of mines already opened. The mines to be sure are not opened in the most favorable places ; but while new ones better situated could be opened the old ones could be pushed forward and afterwards by connecting both sets the points for attacking the coal would be multiplied, the room for a greater number of miners would be provided and a large yield be made quickly possible. The present tramroad leads with the help of three inconvenient inclined planes to a very unsafe sea port two miles distant, at Kayanoma. From more judiciously placed mines near the present ones an equally short railroad could be built with a gentle down grade to Shibui harbor, with perhaps a single inclined plane at the lower end that could be turned to account by making the loaded coal cars draw the empty ones up to a height great enough to let them run back to the mines on another line by their own weight. Other mines in the Chatsunai valley would be even more accessible. Shibui harbor and the adjoining Chatsunai harbor, though small, are already much better than the Kayanoma harbor, and in their present condition offer perhaps equal facilities for the distant shipment of coal on a large scale to any offered by the Ishcari river. One or two steamers drawing not more than a dozen feet could lie safely in the Chatsunai harbor at all seasons, and that would suffice for a large colliery ; whereas the shipment by the Ishcari river is closed by ice during four months of the year, and the bar at the mouth has at favorable seasons only twelve feet of water.

But the Chatsunai and Shibui harbor could be enlarged to a much greater and for the purpose very ample size ; though it would still be a small one, only six acres of land-locked water 25 feet deep, and ten acres nearly land-locked, with much more space, however, that would be thoroughly sheltered from the most dangerous winds. For that purpose it would only be necessary to build a breakwater 375 feet long in water at most 25 feet deep from the northern head of Shibui harbor to the north end of an outlying ledge of rocks, and some 250 feet more to connect the ledge with other smaller rocks in line with it. The stone for building the breakwater would be found in any desired quantity in the cliffs at its shore end. The harbor could not be silted up by the only two insignificant streams that empty into it. The cost of the short railroad and little breakwater would clearly be very much less than that of even the shortest railroad in the Ishcari Valley from the mines to navigable water.

Last summer we made at your request the first survey for such a railroad in the Ishcari Valley, and staked out as the most certainly feasible a line from Poronai to the Ishcari River at the mouth of the Horumui. The line has constantly a down grade, is among hills for three or four miles at the upper end but very level the rest of the way and avoids as much as possible the great swamps of the Ishcari Valley ; and yet without being very crooked on the whole, is 17½ miles (7 ri) long, and with rolling stock would cost for steam perhaps $700,000, or for horses

$250,000 or $300,000. Of course for a number of large mines it would be best to use steam ; but for a shipment of less than 300,000 tons a year horse power would probably be cheaper, owing chiefly to the smaller capital required in a country where interest is high. If, however, many collieries are likely to be opened at once, as the quantity of coal would amply justify (in case the market is satisfactory) ; it is very greatly to be hoped that it may be found practicable to build a railroad straight across the great swamps to the Ishcari river below the mouth of the Bibai. For not only would the distance from the mines to the river be only about thirteen miles (5¼ ri), though the navigation from that point (with about ten feet of water at ordinary times) would be more than thirteen miles longer than from the mouth of the Horumui (with perhaps a trifle greater depth) ; but with a bridge across the Ishcari, the line could be at any time carried straight on, across swamps again, 17 or 18 miles (7 ri) to the mouth of the Ishcari. From there coal could be sent to sea all the year round ; while on the other hand the navigation from the Horumui would be closed by ice for about four months every winter, and the coal brought out of the mines would consequently have to be piled up at that season in great heaps and be exposed for several months to the deteriorating influences of the weather, a very great drawback. The railroad line to the mouth of the Horumui might also be continued at any future time to the mouth of the Ishcari but would be something like five miles (at least), or 2 ri, longer than the straight line. The digging and working of a canal from the coal to the Ishcari seems rather impracticable from the number of locks that would be required by the descent.

For a large shipment of coal from Ishcari it would clearly be necessary to improve the entrance to the mouth of the river; since the bar at the best seasons has only twelve feet of water. It seems, however, quite practicable to build out piers or jetties in such a form as to enable the current of the river to keep a channel scoured out to a sufficient depth and enable it to discharge the river silt into water so deep that in many years no harm to navigation would result from it; and the expense of such works and of keeping them in proper repair would probably be much less than that of building a few miles of railroad; for example, the nine miles along the shore from Otarunai towards Ishcari, part of a line that has been proposed for shipping coal at the imperfect harbor of Otarunai. Within the mouth of the Ishcari river there is an ample space of deep perfectly sheltered water for a very large number of vessels.

It has also been proposed to build a railroad from the coal to the excellent harbor of Mororan; but the distance from the Poronai region would be nearly a hundred miles and the consequent tax on the carriage of every ton of coal would be very heavy, and though the port would be much more convenient for points on the east coast of Nippon, the voyage to Shanghai, the largest coal market at present, would be scarcely shortened. It is, however, not improbable that good workable coal may be found nearer to the Pacific than Poronai, so as to lessen the distance from Mororan to perhaps 75 miles; but even then the advantages of the Ishcari route would be much greater. The line to Mororan would in general be very easy to build, over a very level country, especially for the fifty miles along the seacoast, except two small hills, but there would be four or five bridges to build over difficult streams along the coast, besides several smaller ones. It is likely that the cost of building and working those fifty miles of railroad would be greater than that of making and keeping in repair a good artificial harbor on the open sea shore somewhere near Yunbuts, at the point nearest to the coal; a port that would also be very convenient in some respects for Sapporo, though still about forty miles distant, and would be an outlet for the products of the Ishcari valley in general.

All things considered, however, it seems clear that Ishcari will be found the most favourable point for sending the coal and other products of the great valley to sea, and that the improvement of the harbour would be fully justified. It is also clear that sooner or later a railroad will be built from it not merely to Poronai and the Ichikishiri, but much further northward through the valley, opening up a great many good points for coal mining, both in the Nuppaomanai, Bibai and Sankebibai fields already surveyed, and still further north in the thick beds and fine coal of the Sorachi and even beyond in the Uriu valley; while a branch may cross the low pass at the head of the Sorachi and open up the fine farming region of the Tokachi valley, which has no satisfactory port as an outlet of its own, but would find a market for its products in the future populous mining region of the Ishcari valley. Foreseeing, then, the inevitable destiny of Ishcari to be the great port and town of the Ishcari valley and of Yesso, it is possible to take with due order and economy the proper steps for bringing the result about.

b. Political Obstacles.—The political difficulties in the way of working the Yesso minerals are that they belong to a country where capital is comparatively scarce and unaccustomed to modern methods of business and where treaty stipulations make it nearly impossible for foreign capital to be employed. As foreigners are denied by treaty the right to buy and sell in the interior of Japan and cannot without complete naturalisation validly agree to subject themselves either bodily or in their property to the jurisdiction of the empire, it is by strict construction impossible, of course, for them to work mines even under the form of a company incorporated under Japanese laws. To be sure, as the stipulation about buying and selling in the interior is one made in behalf of the Japanese government, the same government might without waiting for the complete revision of the treaties grant to foreigners the right of forming or joining such mining companies; but in case of any dispute between such a company and any body outside of it or between the members of the company it is clear that any foreign shareholder might claim to be (with his property) solely under the jurisdiction of his own government. If the Japanese government, even in view of the manifold advantages to be gained, should be unwilling to yield so much, perhaps a special agreement could easily be made with the foreign governments that foreigners might be allowed to join such mining companies (of limited liability) with the understanding that the property of the companies should be subject to Japanese jurisdiction. Possibly even under the present regulations mining property might be represented in such a form as to be practically purchasable by foreigners at the open ports. For example, government bonds or other securities might be deposited there as a guaranty for money to be employed by the mining company and to be paid for according to the profits of the enterprise. If such a conditional arrangement in regard to the amount of interest might, in case of disputes, bring the mines and their management unduly into foreign courts; then the agreement about interest might be made yearly (or periodically) in advance for a definite rate, based of course upon the earnings of the past year or the well assured earnings of the coming year. It is probable, of course, that foreigners would stipulate in such cases for a certain share of the management of the company's business; and that would indeed be a portion of the advantage to Japan from the employment of foreign capital. The best methods of business and of mining now so little known in Japan would become naturalised here greatly to the advantage of the country; and the process would be especially rapid if the property of the companies were to be held equally by Japanese and foreigners. Such an arrangement might be insisted upon in case the introduction of foreign capital were brought about by the special treaty agreement just suggested; but, of course, might be practically disregarded, if the capital were only lent upon securities. Nevertheless, it is probable that many foreigners would prefer to have Japanese equally associated with them in a mining enterprise here, since it would set at rest doubts that might arise in the foreigners' minds as to the treatment that the property of a company not purely Japanese might receive from the government, with whose unswerving justice long familiarity may not yet have given them full confidence. In case, too, of permitting foreign capital to work mines under the proposed treaty agreement, the time for such permission might beforehand be limited, as for example, to twenty-five years, and after that length of experience, the government could again decide whether or not to continue the agreement.

If foreign capital should be admitted to the working of Japanese mines, every body knows very well from what country that capital would chiefly come; from the one, namely, that has the largest amount of capital in excess of the good opportunities for its employment at home. As that is by no means my own country I shall hardly be thought prejudiced by patriotic feelings in urging that foreign capital be so admitted, if it can be done without lessening the extent of Japanese jurisdiction, which I trust will in respect of justice rapidly become satisfactory to the most fastidious foreigners. In America, too, the same question of the introduction of foreign capital has arisen, uncomplicated to be sure by the question of jurisdiction; and silly jealousy has often been felt by individuals that foreigners should be gaining the profit yielded by our mines or railroads. But the advantage is reciprocal, and a merchant might as well complain because his purchaser gets as much benefit from a sale as he does himself; and the desire to enjoy the profit of both sides of a bargain is like the child's wish to "eat his cake and have it too." The working of mines and of railroads is immensely advantageous to a country, increasing its business and prosperity both directly and indirectly, and adding to the revenue of the government. The result is accomplished by means of capital, and if we can hire (or in any way induce) foreign capital to do the work more cheaply than we could do it with our own, we ought to be well satisfied and not begrudge the hire. Of course valuable privileges (such as digging coal) need not be given away for nothing, but may be sold or leased on fair terms to natives and foreigners alike, with the assurance that if some of the privileges should be left to be obtained by foreigners it is because the price is more valuable to the native than the privileges are. If the terms were fair, both sides should be satisfied ; and the nationality of the buyer is as immaterial as it is in a shop where merchandise is sold. But it may be urged that the foreigner takes his profit home and spends it there, whereas, if a native accepted the terms and gained the profit he would spend it here, and so doubly benefit the country. "If!" You might as well say : "If the sky fall, we shall all catch larks." Besides, if the balance of trade is favorable, that is, if there is anything to buy that seems to foreigners worth the money (and mining would tend to bring about such a result), the foreigner will also be likely to spend his profit here and add to the exports of merchandise (the wish of every country, though some other nation must likewise get profit from the transaction) ; and, what is more, if successful, he will bring more capital to spend here to the "benefit of the country."

In regard to the terms on which mining privileges should be disposed of to private individuals or companies by the government, I still hold to the general plan suggested in my report of last summer. It seems, namely, better to lease the mining privileges than to sell them outright; and, for example, to demand thirty cents a ton for all coal mined and sold, a price that would probably not be too high here in the east, where coal is dear. The privilege of taking such a lease at any certain spot might be put up at auction and sold to the highest responsible bidder. In order to discourage the lessee from letting his mines lie idle and unproductive to the revenue and on the contrary a source of expense to the government, he might be required to pay at least a certain sum yearly, say a thousand dollars. The government, on the other hand, should by its engineers keep up an inspection of the mines and mapping of the underground workings, and and see that the mining was not done in a manner unnecessarily dangerous to life or wasteful to the coal. Moreover a regular fee could be exacted in advance for the taking out of a lease, say at the rate of five hundred dollars to a square mile, and in return the government should give a geological and topographical map, a working map, of the land. The search for minerals and the underground surveys would therefore be in the control of the government, where they would be accomplished by a permanent body of geological surveyors with much greater economy and advantage to the public than they could be by the disconnected surveys of private individuals ; and much very harmful speculation of a gambling nature in mineral lands of wholly unknown value would be prevented. The length of time for the leases to run might suitably enough be twenty years.

As for the government's undertaking to work the Yesso mines itself, as has sometimes been proposed, hardly anything could be surer to result in loss, or at any rate in less public profit than the system of leasing. The management would inevitably be more or less in the hands of officials who would be comparatively unfamiliar with its duties and who would be less jealously careful of the government money than a private operator would be of his own. The government has as regards the mines of Yesso ample work for itself in making surveys, inspecting mines, building roads, perhaps even railroads (though it might be still better for them to be built by private capitalists under proper restrictions as regards carriage rates, so that mining by other capitalists should not be discouraged) and in improving harbors or river navigation. Such improvements would be direct benefits to the whole public, would facilitate all kinds of business and industry and would greatly add to the wealth and revenue of the Island. The only ground on which a goverment mine in Yesso could be justified is that it would serve as a school and example for miners and operators; but miners can otherwise be much more economically and correctly taught and operators pointed at less expense to better and more advantageous examples.

6. Maps.—The geological sketch map of Yesso (dated 10th May, 1876) shows with seven different colors the probable extent of the seven rock groups described above. In the margin is a columnar section showing the probable relative thickness and position of the groups; also a table showing the probable amount of workable coal in the different surveys and in all Yesso. The surveys are marked on the map as well as the places where the different useful minerals are found. The map is on a scale of one two millionth and is 1.3 feet long by 0.9 foot wide. It is copied mainly from Matsura's large map of 1860 (which is copied for the coast line, I understand, from the map of Ino made from surveys nearly a hundred years ago, and found to be very good); but the

Ishcari River has been corrected according to Mr. J. R. Wasson's survey, and the uppermost waters of the Ishcari, the Otopchi, the lower Tokachi, and the lower Sorachi according to my own sketching. The copying was mainly done by Mr. Y. Akiyama, but was finished by Mr. T. Inagaki, Assistant Geologist, who also put in the special surveys, the mineral localities and the lettering, and, most laborious work of all, plotted the hundreds of dips that had been observed outside of the special surveys. Mr. H. S. Munroe, lately our Assistant Geologist, besides his other aid during two years of the survey made some suggestions in regard to the coloring of the southern part of the Island, where his surveys and travels had been. The other Assistant Geologists also by their work on the surveys contributed to the final result of this map ; namely, Messrs. T. Yamauchi, T. Kuwada, S. Misawa, J. Takahashi, T. Kada, I. Ban, T. Saitô, J. Shimada, E. Yamagiwa, S. Maëda and S. Nishiyama. The whole work on the map was done under my eye ; but the outlines of the colors are more especially mine. Those outlines, in many places cannot lay claim to much exactness, and the map therefore pretends only to be a sketch ; for, although nearly the whole coast has been travelled round and some long trips have been made across the interior, much of the Island is yet unexplored and has necessarily to be given conjecturally. The map has already been printed, and is the first piece of printing of the kind ever done in Japan.

The geological and topographical map of part of the Ishcari valley (dated of May, 1876, and 3. 10 ft. by 2.59 ft. in size) shows on a scale of $\frac{1}{30000}$ the whole region from the mouth of the Horumui northward to the Sorachi, with the surveyed railroad line laid down, and with the five coal surveys near the eastern edge. The shape of the ground is shown by hundred foot contour lines, and the ascertained and the probable outlines of the great swamp are given. The place of the lowest natural drainage levels of the workable coal beds is marked within the surveys. The Ikusumbets, Horumui and Sorachi rivers are given from our own surveys and sketches, and the Ishcari is copied from Mr. Wasson's survey. A geological cross section is given, and the above written section of the rocks of the Coal Bearing Group is drawn in full. A table shows the amount of workable coal in the several surveys. The work on the map was chiefly done by Mr. J. Shimada under my guidance.

The map of part of Eastern Asia (dated 17th May, 1876) on a scale of one ten millionth, 0.87 feet long by 1.87 feet wide, shows the greater part of the Japanese Empire with some of the surrounding countries, and helps to make evident the commercial opportunities of the Yesso Coal Fields. The map was compiled under my guidance by Mr. T. Kada from various sources that seemed to be the latest and most trustworthy.

It is perhaps well to say here a few words in regard to the spelling and pronunciation of names of places in Yesso, which otherwise may seem very much confused and sometimes unintelligible. The great variations are owing on the part of the Japanese to the exigencies of the best characters they have for reproducing original Aino names, and to their desire to use fine sounding Chinese characters for such names ; and on the part of some foreign travellers to their gross ignorance in regard to the simplest Japanese characters and to their total lack of knowledge of phonetics and to their confusion of different systems of transliteration, in part perhaps also to unpractised ears and carelessness. The simple name of Ichinowatari has been written Ye-gi-no-a-da-ri; and the still easier name of Kayanoma has been printed as Komomi in the " transactions " of a "learned society." The Japanese with their Chinese characters corrupt Yamukushinai into Yamakoshinai, and Stosy (or something like that) into Chitose (with *ch* as in English).

On Matsura's large map of Yesso the genuine Aino names are in general given as exactly as the Japanese characters (and perhaps also Japanese pronunciation) will permit; and in the case of names not already anglicised his spelling has in this report, for the sake of some uniformity, commonly been transliterated according to one method. That method differs in only two or three points from the one adopted in Hepburn's dictionary and by the greater number of foreigners in Japan (though differing much from two systems much favoured by the French and by very many Japanese). Instead of the letter *f* I prefer the letter *h* as giving perfectly the pronunciation of the greater part of Japan; making the syllable *hu* (commonly written *fu*) as in Huurebets (or Fūrebets), Hurubira (or Furubira), and Beruhune (or Berufune) almost the same in sound as the English word *who* (pronounced properly, with the lips protruded or at least stiffened) differing from it only in the fact that the Japanese vowel is made slightly more forward in the mouth (as in the South Carolina pronunciation). Intsead of *wo* simply *o* seems better, since the *w* is not pronounced by the Japanese; as in Aomori (instead of Awomori). In the same way the *y* of *ye* is now only sounded in a small part of Western Japan (where probably the foreigners of 200 years ago picked up the pronunciation, as, likewise, the *f* instead of *h*), and it seems therefore better to write simply *e* (of which the sound is nearly like *e* in the English word *met*, (but more prolonged and made with the tongue slightly more open, as in a drawling pronunciation of that word); for example Esashi, Esan, Uembets. Instead of *g* the common Japanese pronunciation is much better represented by *ng* ; as Komangadake.

Some names, like Yesso, Hakodate, Matsmai, Ishcari, may be said to be already anglicised and no more properly to be changed than Leghorn for Livorno, or Ratisbon for Regensburg, or Misnia for Meissen. The name of Yesso, if it should now be anglicised anew from the present Japanese pronunciation would be Ezzo (for in English a double consonant is not repeated in pronunciation). Dutch or Germans (especially Kaempfer) gave the sound of English *y* by the letter *j*, and wrote Jeso (with *s* probably for our *z*, since the German *z* would be different), or afterwards Jesso (as also Jeddo for Yeddo or Eddo). But where the anglicised pronunciation is a pretty near reproduction of the Japanese, it seems best to favor its improvement by every little change in spelling that has any authority whatever; as, for example to write Hakodate instead of the old Hakodadi (which was probably first written by somebody who could not readily distinguish *d* and *t*, and of which the spelling Hakodatty would give the right pronunciation to English readers still better and unmistakably).

Of Matsmai, a strict transliteration of the best characters the Japanese have would require the vowel *u* in the middle of the word as Matsumai; and in the same way Ishcari by transliteration from Japanese would become Ishikari. But the vowels in question are in pronunciation not what have commonly been called vowels; they are really aspirated or whispered vowels (rough breathings), that is, the same to vowels that so called surd consonants are to sonant ones; and if represented at all, would best be written by an apostrophe or by the letter *h* (which is in English the aspirated vowel corresponding to the vowel written after it). In anglicising, such isolated aspirated vowels disappear altogether, and probably do not exist in original Aino names, having been introduced by the Japanese mode of writing and habits of pronunciation. The same remarks apply to Toshibets (instead of Toshibetsu) and to Yurap (instead of Yurappu). In compounding one word with another, however, the final *u* of the first part may well enough be written even in English as a connecting vowel between many otherwise harsh consonants; as in Shiribetsudake.

In general wherever there is any chance to choose between disagreeing pronunciations, the most euphonious ought to be taken. For example, the name of the capital of Yesso is necessarily written in Japanese Sa-tsu-po-ro, and in their Chinese Satsu-horo; but, as the ordinary interpretation of the former spelling would justify, is often pronounced by them Sapporo, which is, if I mistake not, also a common Aino pronunciation, though Satporo is more correct. Sapporo should of course, be taken into English rather than any of the other abominations.

In view of the corruption of the aboriginal names that has taken place and in some cases their complete transformation and the total concealment of very appropriate and interesting meanings to such names, much might be said in favor of habitually translating names of that kind rather than trying merely to transfer their sounds from one language to another. In a few cases the Japanese can write with Chinese characters the Aino pronunciation and at the same time the Aino meaning, or nearly so; as, for example, Bibai, fine (mussel) shell.

By an oversight, some of the maps bear the spellings Fuurebets, Furubira, Berufune, Matsumai, Awomori, and Ohotsnai (instead of Ohotsunai).

7. Results of the Survey.—One of the chief results of the survey is a knowledge of the fact that there are probably a hundred and fifty thousand million tons of workable coal in Yesso, or about two-thirds as much as the coal of the same thickness of the famous fields of Great Britain, which, are such an immense source of

wealth to that country, far the largest coal producer in the world. That amount of coal in Yesso would enable the island to yield the present enormous yearly product of Great Britain for nearly a thousand years ; and in doing so would bring to the Government, at the rate of thirty cents a ton, thirty thousand million dollars of revenue, in addition to other still greater benefits to the Government and profit to the public.

Indeed, the proof of the probable existence of so much coal in Yesso may well be considered a matter of great national importance, not only assuring in the future great wealth to the empire, but having in the immediate present most important financial bearings. If, as some men thought last winter, even the publication of a necessarily meagre unprofessional report on the mines of Japan could produce an unfavourable effect on the credit of the Government, it is not too much to hope that the same credit may be improved by the detailed demonstration furnished by the maps, sections and reports of our survey.

In case any men in Japan should still be so narrow and unenlightened as to look with contempt upon what seems to them so unpractical and useless as surveying and mapping, it may be worth while to point out how the effect of our survey on the government's credit may alone be worth in money (to which such sordid minds must have every thing reduced before they can appreciate it) far more than our outlay has been. Suppose the government should wish to borrow money abroad, where it is cheapest, not necessarily to increase the public debt, but, say, to replace the present debt at a lower rate of interest. Is it not clear that the rate will be low in some proportion to the known wealth and resources of the country ? Even if faith be lacking in the steadfast integrity of the government, the existence of certain material resources enables them to be pledged in some safe manner as security, and with security the rate of interest must be lower. The coal of Yesso when generally known to the public might then well enable the government to borrow money at a lower rate than it could without it. If the present very high rate were lessened one per cent., that would amount on a loan of three hundred million dollars (not an enormous one for an empire, and only one-fifth of a cent for each ton of the above-mentioned amount of coal) to a yearly saving of three millions of dollars, or, roughly, ten thousand dollars a day. But even if the effect of public information as to our Yesso coal were only one-tenth of that, it would still amply repay within a couple of months the whole expense of the survey.

But a few ounces of brains outweigh millions of tons of coal; for nobody wishes to lend money to a rich rogue or to a rich fool; and for good credit it is necessary to have a reputation not only for wealth and integrity but for intelligence and enlightenment. Perhaps, therefore, the financial effect of that vast amount of coal would be fully equalled by a knowledge that the government had had the prudence and wisdom to have a geological survey made at all, in order to ensure, in the very worst event, that the money of the public should not be foolishly wasted in unwarrantable mining speculations. It is not improbable either that even money lenders may be affected by the general reputation for intelligence that a nation would acquire by encouraging investigations of still more purely scholarly interest. The Kaitakushi will at least have the credit of carrying out in respect of our survey (until last winter at least) the recommendation of the American adviser (General Horace Capron) whom it had the fortune to engage five years ago, and who had the sagacity to insist upon such work at the outset rather than to plunge into costly and unjustifiable (but perhaps more obviously "practical") mining ventures, as some desired to do. The Kaitakushi has the credit of beginning and carrying nearly to completion the first geological survey of the kind undertaken by any native Asiatic Government, and of publishing the results to the world, not merely for the benefit to the finances of its own Government, but for the better information of all who are interested in geology.

The Yesso trigonometrical survey, begun by the recommendation of the same adviser, and the first begun in Japan or under any native Asiatic Government, may likewise, if it be still carried on, by its effect on the security of life and property along the sea coast, on the planning of roads, on the land revenue, both directly and indirectly, and on geographical learning in general, be of benefit even to the reputation of the Government in a degree very far outweighing its cost.

But aside from the information or reputation gained directly or indirectly by the Government or the public, one very important result of the geological survey has been the training it has given to a dozen Japanese young men, the first Asiatics who have given themselves to the study and practice of geology. Their progress has been such as fully to confirm me in the hope I expressed in a report nearly three years ago that Japan would "become in a few years independent of foreign countries in their profession." That is, in making geological surveys, for, of course, in one sense no country in the world is independent of all others in respect to geological learning. And by "becoming independent in a few years" of course, it is not meant that in so short a time could be acquired the highest skill for which in other countries a life time is justly not thought too much. But it is now well assured that even long before these same young men reach to middle age (but "a few years" certainly) they may become very amply competent to make and teach others to make wholly satisfactory geological surveys to any extent that may be required in this country. It may be somewhat longer (if they keep their modesty) before they give to the world any profound theories in regard to the condition of the central portions of the earth or to its earliest history ; but they will be making surveys and maps that will answer all practical mining requirements and that will furnish information with very important bearings on the theories of the earth's history. Eleven of the above named assistants kept on through the survey (as far as health permitted) and with one temporary exception caused by sickness, are still with me at other geological work. They are not only intelligent, industrious, studious and fond of their occupation, and therefore pretty sure to keep on learning and improving in skill; but are so thoroughly honest that their word can be relied on, a matter of the utmost importance in geological work (whatever you may say of it elsewhere), and one that might well have been a source of difficulty.

Their instruction so far has been chiefly a very practical training in which every part of the process of surveying and mapping has been as far as possible reduced to one simple routine which they could readily learn to go through (not merely by rote, but understandingly) and after becoming familiar with it, could understand how to vary afterwards, if under changed circumstances it should be desirable. Although when they joined the survey they had in mathematics but just reached to the study of decimal fractions, and had had scarcely a lesson in drawing, they are now already well competent to make all the field observations and measurements and to map them handsomely and have made good progress in learning to work out the underground geology.

The method used has been the topographical one, as already mentioned in the report of 1873; and in the greater definiteness of its results has fully confirmed what I said then of its superior merits. Although it may seem laborious and slow, especially in a wild country covered with thickets like Yesso, it is safe to say that no other method would have given within the next fifty years anything like such precise information as we now have in regard to the amount of coal in Yesso; (and, unless topographical geology should in that time come far more rapidly into general use than it has in the last twenty years, it is not over likely that any other survey would have accomplished the same result).

Most of our surveying has been done merely with prismatic compasses and pacing and with hand levels ; though commonly checked by a few lines run with a transit and measured with a chain or stadia. The working of the prismatic compass appears to be more exact than the pacing. Mr. Munroe took the pains to count up the amount of the errors in the paced lines of five men in the Toshibets gold survey ; and from his results it may be seen that the extent of the errors averages 1⅞ per cent. for 23 lines of 5,000 feet each, and likewise 1⅞ per cent. for 23 other lines of 2,000 feet each ; but some of the errors are one way and some the other so that their sum is much less than that. The total error of each of the five men was —0.24,—0.4,+0.4,+1.6 and—2.4 per cent. of the whole distance run by each. The average inexactness of the five men was, therefore, about one per cent. ; and that of the four more careful ones about one half of one per cent. Many of the lines gave even a much smaller error, showing the effect of carefulness and of occasionally testing the length of the pace. When it is considered how uncertain some of the other geological measurements must necessarily be, the inexactness of the pacing does not seem very excessive for such geological surveys as ours, if a few carefully measured transit lines are run as a check upon the too great accumulation and inextricable confusion of errors. Suppose, for example, it is desired to ascertain the amount of coal in a certain coal bed. It would take the measurement of a very large number of exposures to enable you to be confident of knowing the average thickness of the bed over a wide extent within two per cent., or say one-tenth of a foot in five feet; and pacing with only ordinary care would give either of the other two dimensions, the length and breadth of the given extent, with greater exactness than that. Of course for opening new mining shafts and the like, the exactness of the preliminary surveying can hardly be too great; but for the identification of coal beds, the calculation of the amount of their coal and the completion of general sections, the methods we have used seem satisfactory.

The following is a list of the maps of the survey (most of them both geological and topographical):

a.—A map of Yesso; dated 1874; size 2.63 feet by 1.99 feet; scale $\frac{1}{1000000}$; Bonne's (improvement of Flamsteed's) projection; reduced from Matsura's map; about five copies for the use of the survey.

b.—Chatsunai and Shibui Harbors; dated 4th May, 1874; size 1.93 feet by 1.54 feet; scale $\frac{1}{1000}$.

c.—Ishcari and Otopchi Rivers; 17th March, 1875; 0.70 × 0.48; $\frac{1}{1000000}$.

d.—Yamukushinai Oil Lands; April, 1875; 1.12 × 1.12; $\frac{1}{5000}$.

e.—Idzumisawa Oil Lands; April, 1875; 1.68 × 1.24; $\frac{1}{5000}$.

f.—Sorachi Coal Field (sketch); May, 1875; 1.11 × 0.98; $\frac{1}{12960}$.

g.—Washinoki Oil Lands; 5th June, 1875; 2.08 × 1.84; $\frac{1}{5000}$.

h.—Makumbets Coal Field; 17 July, 1875; 2.83 × 1.61; $\frac{1}{5000}$.

i.—Profile Section of the Poronai and Horumuibuto Rail Road Line; 24th December, 1875; 18.59 × 0.88; $\frac{1}{5000}$.

j.—Sankebibai and Naie Coal Field; 29th March, 1876; 7.06 × 0.90; $\frac{1}{5000}$.

k.—Poronai and Horumuibuto Rail Road Line; 18th April, 1876; 15.66 × 2.70; $\frac{1}{5000}$.

l.—Bibai Coal Field ; 19th April, 1876 ; 4.75 × 2.60 ; $\frac{1}{5000}$.

m.—Ishcari Valley from the Horumui to the Sorachi ; 9th May, 1876 ; 3.10 × 2.59 ; $\frac{1}{50000}$.

n.—Geological Sketch Map of Yesso (in colors) ; 10th May, 1876; 1.30 × 0.90; $\frac{1}{2000000}$.

o.—Poronai Coal Field (including selected cross sections); 10th May, 1876; 2.91 × 2.31; $\frac{1}{5000}$.

p.—Ichikishiri Coal Field; 13th May, 1876; 4.29 × 0.90; $\frac{1}{5000}$.

q.—Nuppaomanai Coal Field (including Kawanai); 6th May, 1876 ; 3.54 × 3.52 ; $\frac{1}{5000}$.

r.—Part of Eastern Asia with commercial position of the Yesso Coal ; 17th May, 1876 ; 1.10 × 0.87 ; $\frac{1}{10000000}$.

s.—Kayanoma Coal Field (including selected cross sections) ; 18th May, 1876 ; 3.81 × 3.40 ; $\frac{1}{5000}$.

t.—Reconnaissance of the Toshibets River (sketch) ; 23rd May, 1876 ; 1.20 × 0.95 ; $\frac{1}{100000}$.

u.—Esashi Gold Field ; 29th May, 1876 ; 2.35 × 0.90 ; $\frac{1}{5000}$.

v.—Upper Part of Musa Gold Field ; 7th June, 1876 ; 3,50 × 1.56 ; $\frac{1}{5000}$, *w.*—Lower Part of Musa Gold Field ; 7th June, 1876; 3.46 × 1.56 ; $\frac{1}{5000}$.

x.—Kawanai to the Ishcari River; 7 June, 1876 ; 9.42 × 1.70; $\frac{1}{5000}$.

y.—Toshibets Gold Field ; 8 June, 1876 ; 4.90 × 2.52 ; $\frac{1}{5000}$.

z.—Kudoö Gold Field; 8 June, 1876 ; 3.38 × 2.54 ; $\frac{1}{5000}$.

The following reports of the survey have also been written :

a.—The First Season's Work, dated 25th December, 1873 ; printed octavo pp. 46.

b.—Yesso Coals (chiefly chemical, by Mr. H. S. Munroe, including 44 assays and 12 ultimate analyses); April, 1874; pp. 29 and 3 large tables.

c.—Geological Trip through Yesso; November and December, 1874; pp. 237 and 2 large tables.

d.—Yamukushinai Oil Lands; 17 April, 1875; pp. 13.

e.—Idzumisawa Oil Lands ; 26th April, 1876 ; pp. 8.

f.—Washinoki Oil Lands ; 29th April, 1875 ; pp. 13.

g.—Sketch of the unfinished Maps and Reports ; 4th May, 1875 ; pp. 10.

h.—Gold Fields of Yesso (by Mr. Munroe) ; 10th May, 1875 ; pp. 60.

i.—Makumbets Coal Field ; 17th July, 1875 ; pp. 11.

j.—Daily Progress in 1875 ; 20th July and 7th October, 1875 ; pp. 78.

k.—Geological Notes (by Mr. Munroe) ; 29th January, 1876; pp. 52 and pp. 47 of tables.

l.—Sankebibai and Naie Coal Survey ; 12th April, 1876 ; pp. 11.

m.—Bibai Coal Survey; 31st August, 1876; pp. 18.

n.—Nuppaomanai Coal Survey ; 2nd September, 1876 ; pp. 16.

o.—Poronai Coal Survey; 3rd September, 1876; pp. 21.

p.—Ichikishiri Coal Survey; 3rd September, 1876; pp. 9.

q.—Kayanoma Coal Field; 6th September, 1876; pp. 29.

r.—This report; 17th September, 1876; pp. 116.

It appears, then, that the total area of our maps is over 190 square feet, the greater part of which is as closely filled up as clearness would permit with minutely measured, complicated work, which required, however, in addition to what has been copied into the final maps a very large amount of mapping, section drawing and careful measurements upon the rough sheets. The lettering has been done in both Japanese and English and is very full, so as to make the work easily understood; yet, it is hoped, not so heavily written as materially to obscure the topographical and geological facts. Of the reports there has been a total of about 770 pages of print.

There are over 180 two hundred page note books of the survey and probably some 250 sheets of rough plottings besides a large quantity of manuscripts of other kinds; nearly the whole of which still belong to the Kaitakushi. As they are, however, wholly useless in all probability to the Department, I would strongly urge that they be returned by a very trifling effort of liberality to the present geological assistants, either collectively or individually, who are the only Japanese capable of making any proper use of them and who would feel more interest than anybody else in their careful preservation and in holding them ready for any possible reference to them that the government might need in the future. The notebooks are all indexed; and the notes are arranged on such a plan that reference can instantly be made to the original place where any surveying station or mineral locality is mentioned, no matter in what book or by what assistant the note was written. For the name of the station is simply the assistant's initial with the number of the volume and folio of his books and a small letter to distinguish the notes of any one folio.

Besides the work on the maps and reports, in the field and in the chemical laboratory, we have collected and arranged something like 8,000 specimens of Hokkaido minerals (including about 2,000 previously in the possession of the Kaitakushi). They are chiefly rock specimens but partly fossils and minerals proper; and have been arranged according to the geological groups. Each piece has had a small label securely gummed upon it to ensure against any future mistake in regard to its locality; and larger separate labels have also been prepared to some extent. But we have not found leisure to complete the arrangement, the separate labelling and the trimming of the specimens; so that the collection still is more a useful than an ornamental one, and less useful to the public and less convenient than when the separate labels shall be all properly finished, so that they can be read from the outside of the glass cases without handling the minerals.

It may seem very absurd to have written this final report in the field, at a distance from Yedo and without access to the mineral collection, to the finished maps, and to the greater part of the rough manuscript notes of the survey, to say nothing of access to books in general; but rather than trust to finding any future opportunity for writing under more favorable circumstances, it has probably been better on the whole to finish the work, even so imperfectly, with such leisure as could be obtained now from the more and more pressing duties of a new survey for another branch of the Government.

I have the honor to be,
Sir,
Your most obedient servant,
BENJ. SMITH LYMAN,
Chief Geologist and Mining Engineer.

Takada, Echigo,
17th September, 1876.